



Marlin's Fish

Biology Notes

Sumit Singh

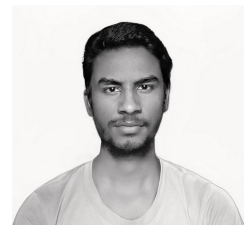
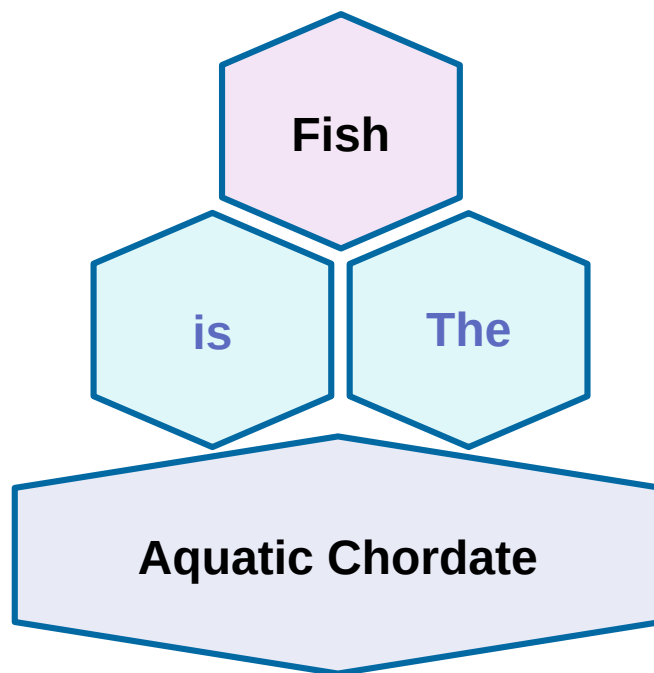
A pdf based notes on fish biology

Marlin's Fish Biology Notes

IFAS

A Pdf Based Text-notes of Fish Biology On Current Syllabus 2023

B.sc First Year



Sumit singh

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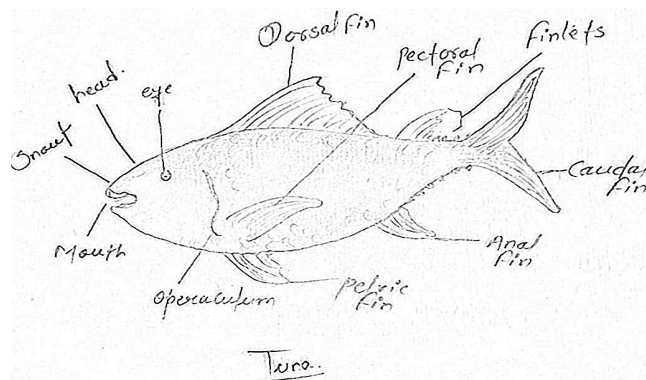
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INTRODUCTION

What is fish ?

Fish is cold blooded (Ectotherms) vertebrate creature which breath with gills and swim with paired and unpaired fins. Fishes are Ectotherms which means they are unable to regulate it's own body heat by metabolism and ultimately depend on surrounding source of heat. The fish metabolic heat loses with environment so the external temperature is just similar to internal body temperature but here is an exception that tuna fish and shark can generate their own metabolic heat and therefore they can regulate their internal body temperature by it's own, both are called as endothermic.

The total number of fish species is really overwhelming but around 34'000 fish species are commercially important species which are distributed in freshwater fish, marine water fish and brackish water fish. The first fish belongs to the agnatha (jawless) which is **Haikouichthys**, reported in china. Agnatha or jawless fish had lack of true jaw and also true paired fins but one of the class of this fish is still exist which is called as cyclostomata. The golden age of fish is Devonian period because during this age of period, fish and also other important aquatic characteristics evolved with several features which we recognize now. Around 450 million year ago jaw appeared in fishes called as jawed fish or **placoderms**. The study of fishes is termed as **ichthyology**. Fisheries is the culture, management and harvesting of fish and it's related organism. China is the first country in the world which produce largest fish production, India become second largest fish producing country but the exact data may vary according to yield per year. World fisheries day celebrated on 21st November.



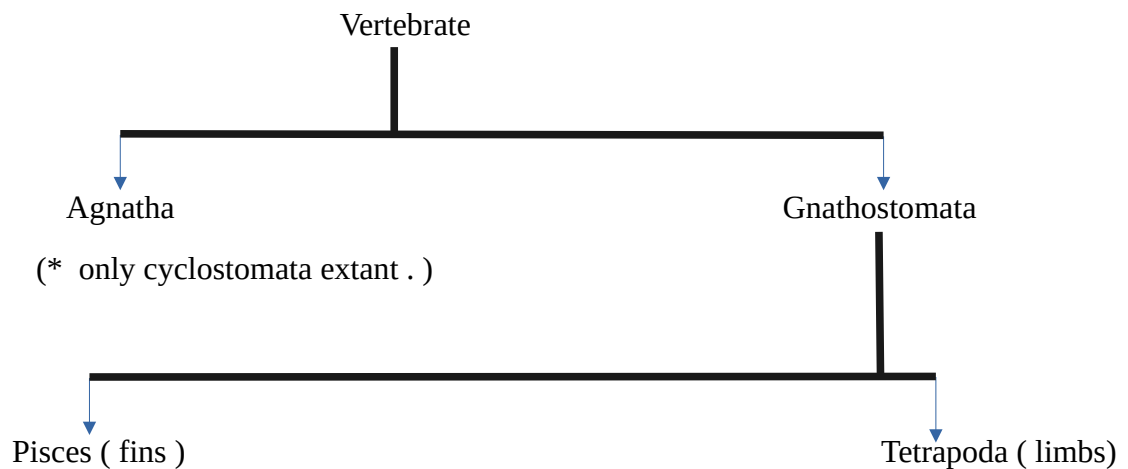
Fish primarily lives in water environment but some fishes like those who belongs to Dipnoi (sarcopterygii) or Lung fishes are adapted to survive out of water easily. The water is such a vast open world which is greatly featured for verities of life along with fish for example, many invertebrates; prawns, lobster, crabs, snails and many aquatic plants.

Classification of fishes

Fishes are vertebrate creature which means they possess well developed notochord at embryo and vertebral column at adult stage of life but in agnatha and cephalochordata notochord persist throughout the life. Fish and other advanced vertebrate organism have notochord at embryonic development which replaced in vertebral column at adult by successive development. Fishes are divided into agnatha and gnathostomata on the basis of presence or absence of jaw. If fish/organism posses jaw in their mouth then fish called as gnathostomata or jawed fish and when fish don't have jaw in their mouth called agnatha or jawless fish.

According to natural selection, agnatha fishes become extinct but only few species are present nowadays which is sea lamprey and hagfish.

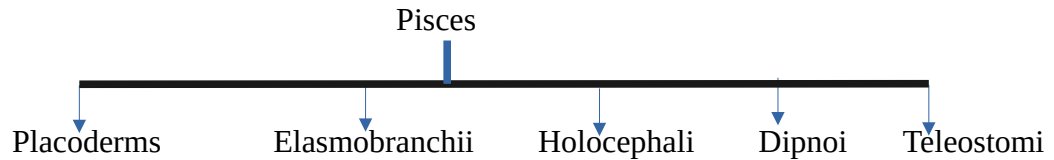
Classification of fishes :-



Gnathostomata having jaw and further it divided into Pisces and tetrapoda. Tetrapoda are organism which have limbs, including mammals, aves, reptilian and amphibians.

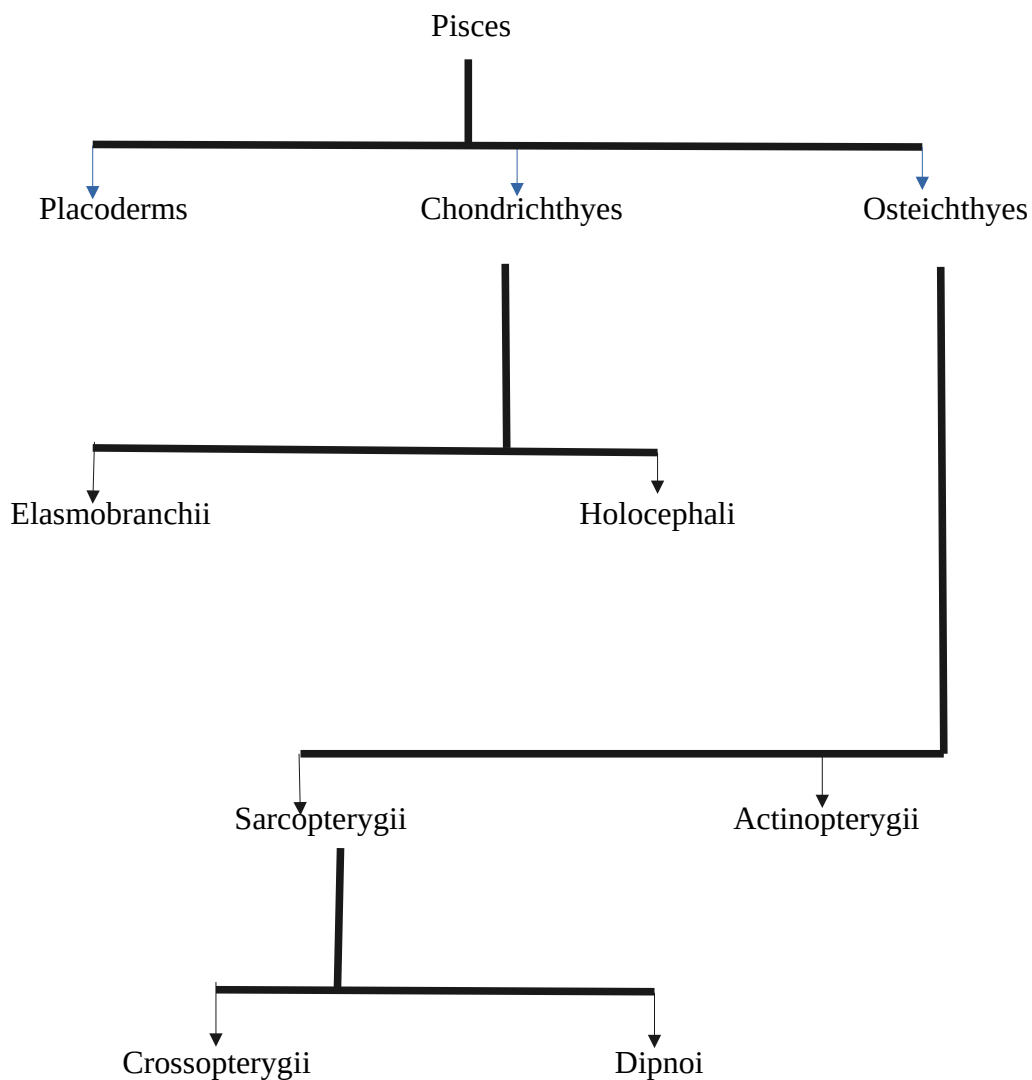
Pisces having fins instead of limbs and also possess gills but in some fishes like dipnoi or lung fish present lung (neoceratodus)/ lungs (lepidosiren, protopterus) either with gills or independently. Ostracoderms and placoderms are two major extinct fish group where ostracoderms belongs from jawless section while placoderms from jawed section. It is noteworthy point that in placoderms included Acanthodii, coccosteus and pterichthys and unfortunately all of theses species are extinct. Ostracoderms are also known as armored fish because armored appearance and both had bony plate on their body.

It was time where two scientist contribute major important discoveries in classification of fishes but it is older system of classification, Berg and Romer. Berg proposed seven classification system of fishes :-

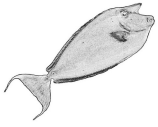


In berg classification system, placoderm are completely extinct so we do not consider it.

But then Romer proposed his classification system “five classification system”. Basically Romer combine elasmobranchii and holocephali into one class called chondrichthyes and dipnoi and teleostomi into one class called osteichthyes .



Furthermore in modern classification system, osteichthyes divided into sarcopterygii (lobe finned fishes) and actinopterygii (ray finned fishes) and so on sarcopterygii divided into crossopterygii and dipnoi .



Biology of fish-1

Need for taxonomy :-

➔ **Taxonomy** is the scientific hierarchical study of identification, classification and nomenclature of organism. Taxonomy is comparative study of morphological character, cytology and biochemical feature of organism. Taxonomy not only gives us a way to classify the organism but also gives immense knowledge about evolutionary relationship, similarities and dissimilarities between organism. It's a organization of organism in particular place through which identification of organism get easier. Taxonomy plays very important role in biology and it's a vast field because it's a fundamental of classification of any organism on the earth.

Hypothetically, Just suppose there are two grocery store, first, have different compartment for various product organization by which a person can easily get their product but in second store there is not such compartmentalization of any product as result customer finds their product hardly. Similarly, Taxonomy provides myriads information about organism but also widely used to classify unknown organism. In simplest, taxonomy consider to be the base of biology because every organism named and their classification just because of taxonomy. Suppose, product are too hard to find in those grocery store where classification and proper tag haven't found to the product. Taxonomy never complete if any one of these system missing, for example without classification how organism named and where it should be placed. So each term that we have seen before like classification, identification and nomenclature are very important to knowing and giving the name of fishes and any organism. If we found a fish, how we can classify that? First, identification of fish consist, looking the primary basic character like recognizing number of dorsal fins, scale type, mouth position, body appearance and then match with pre-existing data. Second, classification involves arrangement and placing the fish in what level of hierarchy. Third naming of that fish, which is a final step, recognize that fish which you found.

So as like grocery store taxonomy is organized way and scientist / person can classify and identify a organism. Even though some previous research had a minor error in the taxonomy study of a fish, *Oncorhynchus mykiss* (Rainbow trout) because before this current classification, Carl Linnaeus (father of taxonomy) had kept this species in *Salmo* genus but recent study reveal that rainbow trout belongs from *Oncorhynchus* genus therefore taxonomy of any organism is not fixed 100%. if any organism re-classified and found to be suit in different location as previous then new classification can possible.

It means that taxonomy of any organism is not permanent, if there is a mistake so it's possibility that it would be corrected in the future.

There are three type of taxonomy in general :- (1) Alpha taxonomy (2) Beta taxonomy (3) Gama taxonomy . Alpha taxonomy is study about character , Beta taxonomy study about arrangement of species and Gama taxonomy study about evolutionary history .

The **need of taxonomy** in study of any organism play important role because through use of taxonomy data we get accurate result of given species and this is the most useful thing in the study of a species by the scientist because they can identify easily a unknown species , for example . There are following factors why which we have need of taxonomy :-

- (1) Taxonomy identify and distinguish between flora and fauna means we can understand that particular species belongs from either plant kingdom or animal kingdom.
- (2) It help to study of unknown organism or species by study of their character and appearance.
- (3) Taxonomy can also help in assessing the number of species present on the earth.
- (4) In identifying of location of specific species of either plant or animal.
- (5) It helps in identifying of native or exotic species.
- (6) And finally one of the best application of taxonomy is that it avoid rediscovery of already discovered species.
- (7) Even we use taxonomy for differentiate the one species to others and also for giving the scientific name of organism .

That's why we have need of taxonomy .

Binomial nomenclature

Binomial nomenclature is the system of giving scientific name to the organism according to their classification. As name implies Bi means TWO and Nomial means NAME. The binomial nomenclature provides scientific name of particular organism therefore it's now easy to distinguish whether a fish come from. Because every organism has common name but it is not the perfect name to use and recognize any organism biologically. So any organism should be very specific therefore classification and identification become easier and this problem solved by binomial nomenclature.

Father of taxonomy is calrolus Linnaeus. But the term taxonomy given by candolle.

There are following system of binomial nomenclature:-

- (1) Binomial nomenclature name contain two word GENERIC and SPECIFIC .
- (2) First letter of generic name should always be in capital letter while first latter of species should be in small later.
- (3) if binomial nomenclature used to gives name of organism in book, paper or printing type use italic latter but in the writing system use underline separately.
- (4) Generic and specific word should not have less than three letter or more than twelve letter.

Example;- *Labeo rohita*, *Catla catla* , *Clarias batrachus* etc.

Data requirements for classifications of fish and methods for collections of taxonomic data

The classification of any organism require the specimen on which experiment and system will work. the data for classification of fish are following :-

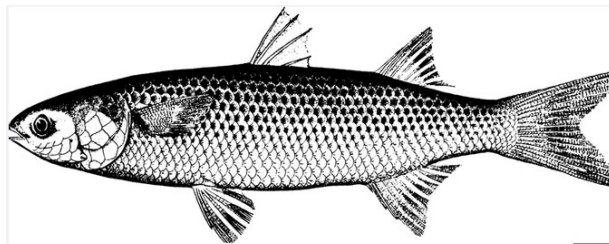
(1) Collection of fish :- In the collection of fish, we collect a desired specimen or fish. The major objective of the collection of fish is using all the gears combinations. Two types of gears are employed in capturing the fish for identification or other purpose, active and passive categories. Passive gear(no machines work) is usually set and left stationary for a period and commonly used gear are gillnet and traps, these gear need almost no energy from machines but need hard work from person who capturing it. Active gears used in the large boats and systems, are seine nets, trawl nets, dip nets, hooks and line and electric fishing. The active gear perform by machines and mechanical energy. Different factors affect fish classification such as water depth, conductivity, water clarity, water temperature, fish size and fish behavior.

(2) Identification of morphological character :- In this method we identify the external basic character of our specimen or fish. Let's consider that we have collected a fish and we don't know about this fish so the first thing to do is looking and identifying the external form or character. In this morphological character we found that there is :-

- (1) Double dorsal fin first is spiny and second is soft ray fin
- (2) Caudal fin is deeply forked
- (3) Lateral line invisible and almost absent
- (4) Head is blunt

- (5) Body of fish somewhat elongated
- (6) Mouth is small and terminal
- (7) Having ctenoid scales but absent on head .
- (8) Whiter light colour at ventral side and dorsal side is dark.

After knowing these external character you will be able to classify the fish BUT these data is not completely enough for identification but just we have supposed so we are considering it. On the basis of these morphological character the specimen exhibits more and more relation with MULLET fish .



After identification and classification on the basis of character, The fish scientific name and classification would be :-

kingdom:- Animalia

phylum:- Chordata

class:- Actinopterygii / percomorpha

order :- Mugiliformes

genus:- Mugil

species:- Mugil cephalus

(3) preservation technique :- after classification of fish we move to preserve that specimen for future classification and taxonomic data. Fish must be killed for preservation. Killing the fish is an ethical process, kept that fish in “formalin solution” containing water and formalin. The formalin is sparingly toxic chemical so water is needed to fix the proper concentration. 10% concentration of formalin is used to preserve the specimen. For preservative we use formalin solution (1 part formalin and 9 part water combination). After making the preservative, the fish is kept into a big mouth jar or bottle and formalin solution is dipped the bottle with specimen for days and weeks depending on size and type of specimen. The formalin solution is penetrated in cell and reacts with proteins to form stable bonds and compounds which prevent the overall cell decay process. After weeks and days ,

the formalin solution removed from bottle and specimen washed with saline solution and water to remove formalin from specimen and then the formalinated specimen dipped in bottle with ethanol and isopropanol because ethanol is long term preservative. The position of fish in the bottle is head lower and mouth up positioned.

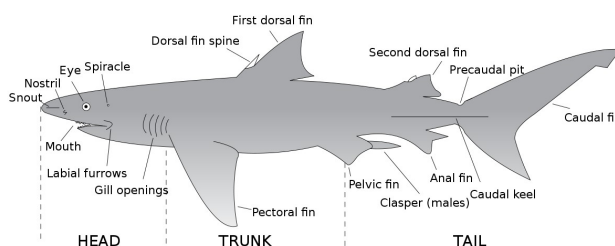
(4) labeling :- This is the last step of this technique, In this step the bottle labeled by following writing :-

- (a) name of collector
- (b) place of collection
- (c) date of collection
- (d) name of fish .

Study of external morphology of typical elasmobranches and typical teleost

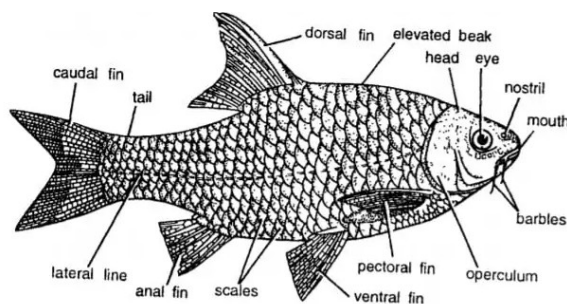
- **External morphology of Elasmobranchii**

- (1) Endoskeleton made of cartilaginous by chondrocyte cell (type of fibroblast cell) .
- (2) They possess placoid scales made of enamel like material called vitrodentine on their body.
- (3) Operaculum absent .
- (4) Spiracles are present which are positioned behind the eyes and they open into first gill chamber.
- (5) Gill slits are present, number can vary depend on species .
- (6) Cloaca present, clasper present in male fishes not in female .
- (7) having high concentration of urea in the blood and it gain advantages of this concentration in osmoregulation.
- (8) Elasmobranchii don't have swim bladder but maintain himself in the column of water body by liver oil .
- (9) Mouth present at ventral position.
- (10) caudal fin is heterocercal .
- (11) mainly found in marine water .
- (12) mostly they are active swimmer and they use ram ventilation (a process of gas exchange) .
- (13) some of elasmobranchii are herbivorous and carnivorous.



- **External morphology of teleost**

- (1) Endoskeleton made of bony of osteocyte cell .
- (2) Operaculum are present on both side of the head.
- (3) Cloaca and clasper are absent.
- (4) Swim bladder present but absent in catfishes and some other fishes.
- (5) Caudal fins is mainly homocercal but verity of caudal fin are exist.
- (6) Spirals are absent.
- (7) Mouth positioned mainly at terminal, superior, inferior and others.
- (8) They have cycloid scale, ctenoid, gonoid and cosmoid.
- (9) Found in all type of water source.
- (10) Gill slits are absent .
- (11) Lateral line found from tail to head .
- (12) Scales are absent on head .



Skin coloration

Majority of fishes are vividly and brightly coloured. Colouration is one of the most common phenomena found among the fishes. The enormous range of colour and patterns that produced in fishes are generally related to their habits and genetics. Normally fishes are darker on the dorsal and lighter on sides or ventral side.

Fish skin colour are very diverse in nature and fishes are greatly divided through it's colour. Some fish have same colour on their entire body while others have combination of colour. The bottom dwellers are often strongly coloured above and pale below. Generally male are strongly coloured due to Y-chromosome than female one but it is not one of the reason.

There are two main source of colour production in fishes:- (1) **chromatophore** and (2) **iridophore**.

(1) Chromatophore :- As name implies that chroma means colour and phore means pigment so overall meaning indicate the pigment which carrying colour. Chromatophore is the unit of pigmentation for colour in fishes and most other aquatic life. mainly chromatophore present in *dermis and also on epidermis* layer of skin . Chromatophore are also responsible for different colour of fishes like yellow, green, red, black etc.

There are mainly two pigment cause colour under the chromatophore which is carotenoid (organic pigment) and melanin. Carotenoid make Red and Yellow colour while melanin makes black and brown colour in fishes. Carotenoid is obtained from plant diet that's why herbivorous fishes are strongly coloured but melanin synthesize inside the body by tyrosine amino acid.

let's take a look on pigment which cause this coloration :-

xanthophore :- Involve yellow and orange colour which is due to carotenoid, obtained from plant diet food.

erythrophore :- red colour which by carotenoid, obtained from plant diet food.

melanophore :- black colour which is melanin pigment, obtained from tyrosine amino acid.

leucophore :- white or silver colour which is due to lack of pigment or also because of purine in cell on body skin.

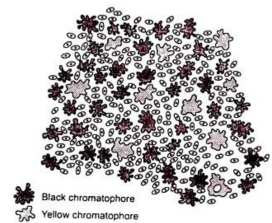
cyanophore:- blue colour.

(2) Iridophore :- reflection system cause by crystal of guanine. You can find this system on mental cavity of bivalve and also on different fishes which used in camouflage. In camouflage fishes, they reflect surrounding colour with irridophore pigment and also used to create same colour with their surroundings by combining the different colour pigment.

melanin is formed inside the body by tyrosine with help of tyrosinase but carotenoid pigment not synthesized by body so fishes gain from foods of plant source. By the combination of different pigment produce different colour of fish skin . For example :-

Gray colour fish :- Combination by red pigment and black pigment(melanin).

Yellow colour fish :- Due to xanthophore or yellow pigment .



Water quality may also play a supportive role in determining the colour of ornamental fishes. Low water quality increases stress on fish and may dull fish colour. The colour of many fishes is also depends on their diets. Such types of diets may contain additional natural pigments to enhance colour of ornamental fishes.

Scales

Fish is complete source of protein, lipid and different other nutrient composition because in fishes consist all the essential amino acid and also almost all polyunsaturated fatty acid. Scales are the external covering of fish skin but it absent in some fishes like catfish and torpedo. The scales of fish is also consider to exoskeleton because its cover the outer skin layer. Scales is one of the best known sensory organ, external covering and protection barrier in fishes which also performs other different functions. The scales has major composition of amino acid that mean its needed amino acid for better function. These amino acid form protein like collagen, keratin and also present connective tissue and calcium carbonate which make it flexible and in some scales its hard.

Scales have many different function for example sensory function, in determining of age, prevent friction with water during swimming and also protect body from pathogens or disease. Fish scales is originate from epidermis and dermis layer of skin. Scales embedded in epidermis layer of skin and this layer made of epithelium tissue and also consist connective tissue which bind scales and provide flexibility of scales. The scale made of keratin protein by two right handed alpha helix and also consist collagen protein for flexibility and stability of the entire scales and also posses calcium carbonate. There are different type of scales are found in fishes according to their genetics and habits.

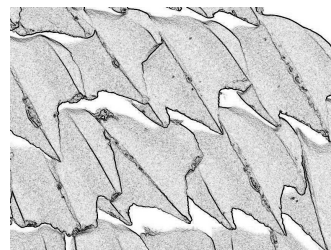
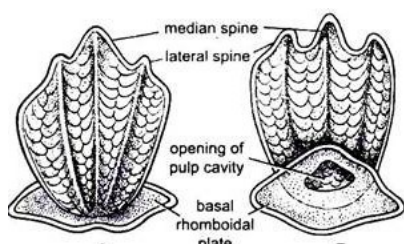
Scales have two region one region is anterior and second is interior region where interior one embedded in epithelium tissue therefore interior id projected in head position and posterior which have different colour pigment and protection barrier mechanism.

Different type of scales are following :-

(1) placoid scales

it's a type of scale found in only cartilage fishes (Shark's). It resembled with tooth like appearance. It is made by three component (1) outer most layer is from **viterodentine** is enamel like material which provide strength and hard stature of scales. (2) middle from **dentin** , (3) Innermost layer of calcium. The basal plate embedded in skin of epidermis and form layer of scales without overlapping on each other. The tooth like appearance and line on structure are present on dorsal side of scales. At the basal side consist one single opening by which essential molecule transported to it.

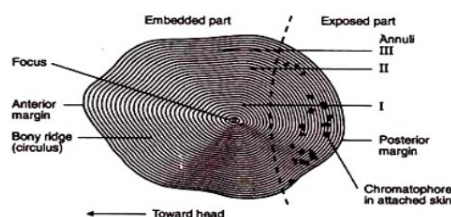
It doesn't overlap on each other and embedded in dermis and epidermal layer of skin. It's very small scale comparison to other scales. Rough like appearance on touching it. These are following image of this scales :-



(2) Cycloid scales

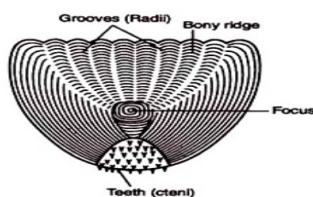
it's a type of scale which is translucent, circular, smooth and common scales in carps, trouts and some lungfish. It is present in overlapping form where it have two part anterior and posterior. Anterior made by collagen and keratin (additional) and posterior made by **calcium** therefore cycloid scales is flexible.

One more important thing about cycloid scales is lining from center called focus to edge . These lining called circuli and the gap between circuli is called groove. The annuli is group of circuli which originated during growth which indicate the growth of fishes.



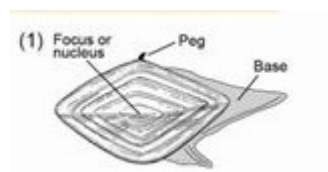
(3) Ctenoid scales

it's more similar to the cycloid scales but just difference in the presence of serrated teeth like structure in the ctenoid scales only at one end. Cycloid scales is smooth but ctenoid scales is rough. As like cycloid scales this ctenoid scales also shows lining of the growth of fish. It is rough to the touch because comb or teeth like structure present at end which called ctenni. It is also made by connective tissue, collagen, keratin and calcium. it is found in spiny finned fish like perch, sunfishes, mullets, bass etc. the teeth like appearance is posterior side which exposed to surrounding.



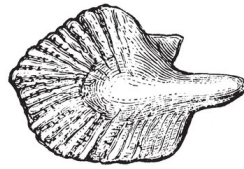
(4) Gonoid scales

gonoid scale is known as diamond scale due to it's appearance. It is made by ganoin and connective tissue and collagen distributed entirely on the layer. These scales are present in primitive fishes like gars, sturgeons which closely shows with placoid scales. Its a hard type of scales because the reason is very clear that ganoin which makes gonoid scale is modified vitrodentine and as we know that vitrodentine is type of enamel so overall ganoin made gonoid scales is hard and its the reason that sturgeons and gars body is very tough and durable.



(5) Cosmoid scales

cosmoid scales found in primitive fishes like latimers and coelacanthiformes. It is made of cosmine which is also similar to vitrodentine therefore it is hard and durable. It is combination of the gonoid scales and placoid scales.



Mouth of fishes

Fish mouth vary greatly in size, shape and position with species. Mouth of fish is adopted for eating their food and on the basis of their adaptation and genetic principle of mouth, fish mouth is different type. Type of fish mouth are following :-

(1) superior mouth is a type of mouth which pointed upward direction means those fish who have superior mouth , their lower lip larger than upper lip . These superior mouth fish are mainly lives at surface but not all species do this and these fishes majority feed plankton's and insects therefore they called as surface feeder. Example are mostly aquarium fishes, angler fish and catla catla and also found in rainbow trout. Note that fish not only depend on their type of mouth adaptation because the fish has superior mouth , they also get food from pelagic. It no mean that type of mouth determines its feature that they feed food only and only from superior rather also feed from other location but majority of cases they get food from surface so called superior mouth.

(2) Terminal mouth is found in most of the pelagic and column swimmer fishes like labeo rohita, common carp and so on. These fishes have terminal positioned mouth means lower and upper lip are in same length and size. These fishes mainly believe in chases to feed. They are also called pelagic fishes in marine water because the nutrient for these fishes are at pelagic column of water. .

(3) sub-terminal / inferior mouth is type of mouth which found in catfishes, most bottom feeders. They have larger upper lip and smaller lower lip so it positioned downward. These fishes are largely predacious fishes which feed from bottom. This type of mouth also called ventrally projecting mouth because of direction of this mouth.

(4) sucker mouth is mainly found in predacious fishes like catfish Loricaridae. This type of mouth is very unique in structure because it has circular based appearance which depends on sucking

process by which it get food. One of the most common example of sucker mouth like hagfish (myxine) and lamprey (petromyzone).

(5) Elongated mouth is long type of mouth where fish get very long upper jaw an lower jaw too. These fishes get benefit of this mouth because it can get it's own food from small rocks and narrow holes. Examples are needlefish and gars

Note :- syngnathiformes like seahorse, seadragon and pipe fishes have elongated snout and not elongated mouth because it's mouth is small at terminal end .

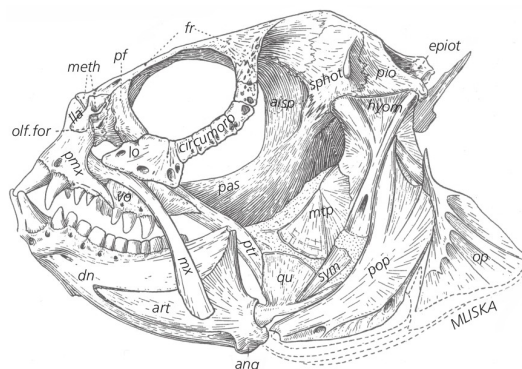
(6) Beak mouth is type of mouth found in mostly gaurami (Anabantiformes) and in kissing fish (gaurami). This type of mouth are small in size which create negative pressure to get their food.

Jaws

Jaw of fish is one of the best example of fish evolution because those fish who had not jaw like agnatha, fishes are completely become extinct. Fish jaws are the organ which helps to get food and in chewing of food. Jaw of fishes and it's type vary according to species to species and on the basis of these jaw fish have their own type of mouth.

Fish jaw are classified into two group first (1) is maxillary jaw or upper jaw and second is mandibular jaw or lower jaw. Upper jaw further divided into two part one is premaxillary which located on front and back side called maxilla. upper jaw made by two skull while lower jaw by three bony structure .

One of other type of jaw is pharyngeal jaw which mainly support in moving the food forward which present in pharyngeal cavity of mouth .



Fins

Fins is locomotory organ of fish which is the true feature of fish. Those organism who has fin instead of limbs and other moving structure, are called true fish but they must possess gills. Fins are greatly vary species to species and type of fishes. The fins is more important for fishes because it is the only organ by which fish can swim and some time fins act like sensory organ. As evolution proceed the armored fins disappear and evolved ray fins and spiny fins according to species.

Noteworthy point is that in some fishes like crosssopterygii and dipnoi means sarcopterygii does not posses true fins, they have lobate fins which is small undeveloped fin present on muscular structure which supported by bone.

Fins have different type and different position according to their function and habits. Spiny fins are the fin that have spines sharp structure dipped in the fin which generally made of cartilage or bones. Ray fin means it don't have spine but it is smooth in appearance and while touching.

There are following type of fins of fishes :-

(1) pectoral fin is type of fins which present on either side of fish behind the operaculum in bony fishes and behind the gill slits in cartilaginous fishes. It is a type of paired fins whose function is that maintaining the swimming of fish, stop suddenly and in turning of the fishes. It may be spiny or ray finned depend on fish species. Sometime pectoral fin have venomous in case of most catfishes or others predatory fishes.

In polynemids (p. Paradiseus) have two type of pectoral fin. One is normal and second is present just beneath the first one which is long and filamentous or thread.

(2) pelvic fin present at lower side or underside of fish. The pelvic fin is also called ventral fin because located at ventral side. It is type of paired fin and it's function is to maintain the pectoral fin function and it's stability. The pelvic fins also used to make stable poster of fish in water column and also balancing of fish body. Sometime it get fused with anal fin to become longer fin but generally is present separated to anal fin and serves different function.

(3) dorsal fin found on back or dorsal position of the fish body. It is unpaired fin and depending on the fish species, the dorsal fin may be spiny or ray finned. The main function of dorsal fin is to maintain the fish in water body and also used to perform proper swimming.

There are variety of modification found in fish dorsal fin, In angler fish this dorsal fin modified into long rod like structure having light emitting system at end but in remora marine fish it's dorsal fin modified into suction system to get attached with shark. This fin help in moving and swimming.

(4) Anal fin is type of fin present lower side of fish body but back to the pelvic fin. It is unpaired fin and used to maintaining the balance of the fish body. It could be longer or shorter depend on fish species. In sharks this anal fin modified into clasper which used for transfer of sperm in female at the time of coupling.

(5) caudal fin is unpaired fin which is most important fin in fishes because this fin participate in movement of fish during swimming, maintain the fish while swimming and gives proper shape of fish. The most important function of this fin is swimming because in marine and freshwater fishes the fish largely depend on this fin to move in water body system. The caudal fin is also called tail fin because it is located at end of the tail.

It is found in different type :-

(a) homocercle caudal fin in this caudal fin upper lobe and lower lobe having same size. For example, perciformes, tuna, mackrel etc.

(b) heterocercle caudal fin in this type of fin upper lobe or upper part of the caudal fin longer than lower one. Example; most of the sharks.

(c) hypocercle caudal fin it reversed of heterocercle fin because in this lower lobe is longer than upper one. Example , flying fishes (exocoetus) .

(d) diphycercles caudal fin have three lobe of the caudal fin. one additional lobe added to the middle position of the fin. This type of fin generally found in bombay duck fish.

(e) truncated caudal tail .

(f) forked caudal fin tail .

(g) lunate caudal fin tail .

Commercially important order families, genera and species of elasmobranches .

Chondrichthyes is cartilage fish that mean these fishes has cartilage made endoskeleton. The Class chondrichthyes divided into two part (1) holocephali (2) elasmobranchii.

(1) Holocephali :- It is primitive chondrichthyes which has only single order and family which is chimeriformes order and chimeridae family respectively. It's a chondrichthyes so it's endoskeleton made by cartilaginous from chondrocyte cell. There are following feature about this holocephali/ chimeriformes :-

- (a) Body is elongated from abdomen.
- (b) Black and Grey colour fish.
- (c) Having large pectoral fin.
- (d) Always found in bottom of sediment.
- (e) Have single gill slits.



In holocephali /chimeriformes and family chimeridae included rat fish, elephant fish, rabbit fish etc .

(2) Elasmobranchii :- It's a Sub-class elasmobranchii have cartilage endoskeleton. Elasmobranchii first divided in two category one is Selachimorpha and second is batoidaea. Selachimorpha further dived into two super-order (1) Squaliomorphi (2) Galiomorphi. The meaning of squaliomorphi and galiomorphi resemble with "shark morphology" .

● **Squaliomorphi** :- it's a super-order. In which included mainly ancient sharks. The name squaliomorphi resemble with dogfish shark shape. It further divided into 4 order. These are following :-

- (a) **Hexanchiformes** :- it's a ancient type of shark have long body and dark in colour. In which included cow shark and frilled shark. Meaning that it has six gill slits .
- (b) **Squaliformes** :- in which included dog sharks. Squaliformes meaning that dogfish shark shape.
- (c) **Squatiniformes** :- in this order included angel shark. The angel shark more resemble with rays.
- (d) **Pristiophoriformes** :- example; saw shark (don't confuse with saw-fish, saw-shark have V shaped snout while saw fish have depressed V shaped snout). The Pristiophoriformes meaning;- "Saw bearer form" . Saw is a instrument that generally used to cut the wood because it has sharp teeth like spike at edge.

● **Galiomorphi** :- it's a super-order In which included modern or advanced sharks. These are following :-

(a) **Heterodontiformes** :- In this order included bull head shark. The meaning of this order is “Different teeth morphology” because the ‘hetero’ means different and ‘odont’ means teeth. The sharp additional teeth present in anterior of buccal cavity and this feature make it different from other shark.

(b) **Carchariformes** :- In which included ground shark and most dangerous shark hammer head shark. The Carchariformes meaning is “sharp teeth form shark”

(c) **lamniformes** :- one of the important order because in which included The great white shark and mackerel shark. “Lamna” means prey so meaning is predatory shark or dangerous nature shark.

(d) **orectolobiformes** :- it is very diverse order because in which included carpet shark, nurse shark, whale shark, bamboo shark etc. “orectolobe” means elongated body so the overall meaning is elongated form of shark.



cow shark

Rays are dorsoventrally flattened cartilaginous fish which different from sharks(generally ; laterally positioned) with verity of feature. One of the characteristics feature of rays is that rays have ventral gill slits (hypotremata) while shark's have gills slits on either side of the head called pleurotremata. Hypotremata is a taxonomic word which generally used to explain that “Hypo” means under or lower and “Tremata” means “Opening in slits form” but pleuro means side and tremata means opening in slits so overall meaning is that hypotremata refers that fish (mostly rays) have gill slits at lower side of the body. Rays are mostly bottom dweller and feeds mostly small fishes, mollusk etc.

The Rays are super order of elasmobranchii which further divides in following orders. Subclass elasmobranchii which divided in to two super order, is Batoidea and Selachii. Further selachii divided in squaliomorphi and galiomorphi. All rays has large pectoral fin and dorsoventrally flattened body. Some rays swim with pectoral fin while other using caudal fins.

Rays are divided into 4 order These are following :-

(a) **Torpediniformes** :- This rays order specialized for producing electric discharge. Include electric rays which has one pair of kidney shaped electric organ at ventral side which discharge electric current. The electric rays swims largely with help of caudal fin instead pectoral fin. The electric organ of electric rays has hexagonal electrocyte cell which arranged in stack manner from ventral to

dorsal side of the body. Ventral side normally negative pole and dorsal one is positive. The current produce by depolarization of electrocyte cell.

(b) **Rajiformes** :- In Rajiformes includes skates which known for making mermaid purse for laying the egg within it. Rajiformes also has large pectoral fin but very reduced caudal fin.

(c) **Myliobatiformes**:- Sting ray is found in this order which is characterized for sting presence at tail and have no such a caudal fin so they swim with large pectoral fins.

(d) **Rhinopristiformes** :- It is featured for saw fish which have saw like mouth and large pectoral fin. The body is elongated but saw shark is different from this fish.

Remember these order :- To-Ra-Myli-Rhino

Commercially important order families, genera and species of teleost

Class Osteichthyes belongs to vertebrate which characterized by fact that its endoskeleton made of bones or osteocyte cell. The osteichthyes are diverse class of fish which found in freshwater, marine and brackish water and contribute great economy. The features already discussed in previous pages. Osteichthyes Divided into two sub-class (1) Sarcopterygii (Lobe-finned fish). (2) Actinopterygii (Ray-finned fish).

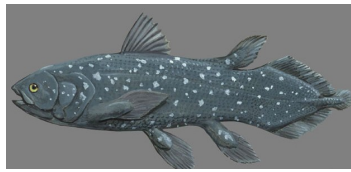
(1) **Sarcopterygii** :- It is subclass of lob finned fish which further divided into two part on the basis of reason that (a) Crossopterygii ; have more muscular and fleshy fin and absence of lungs but (b) Dipnoi ; has lungs and less muscular lobe fin. Sarcopterygii is characterized for it's muscular fleshy lobe fin which is supported by bones. In sarcopterygii includes very ancient type of bony fishes like latimeridae, dipnoi etc.

(a) **Crossopterygii** :- Crossopterygii includes Actinistia or order Coelacanthiformes. In this order present Latimeridae family which is only one of entire order. The crossopterygii also called as finger lobe finned fish because of finger like projection of lobe fin.

In Actinistia have lobe finned structure look like hand fan which is more related with amphibians. These actinistia also called as living fossils fishes and it is going to be rare one. They have large weighed body in black and brown colour mostly and they are deep sea fishes. One of the best morphological character is that they have bony plates on their outer skin. In this order coelacanthiformes have only two species belongs from 'latimeridae' family. Latimeridae named because miss latimer discovered one of the species that's why it called latimeridae but the term latimeridae given by professor smith after study of it's morphological and physiological feature.

They had cosmoid scales but recent discoveries shows that these species have cycloid scales and present **diphycercal** caudal fin. Actinistia go to aestivation process in summer season. Question is how they survive in this process? They use lipids and stored fat in muscles for this aestivation process. Some scientist found that this crossopterygii have

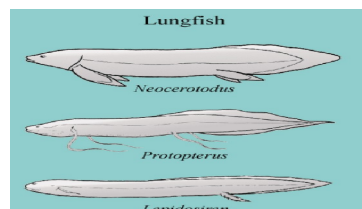
relation between osteichthyes and chondrichthyes because crossopterygii have high concentration of urea in blood but they possess bony plates on body and cycloid scales.



(b) Dipnoi :- Dipnoi also known as Lung fish and unlike crossopterygii, dipnoi has lungs and gills which perform breathing. Dipnoi is also characterized for less muscular type of lobe fin. Dipnoi have three genera (1) *Neoceratodus* from Australia (2) *Lepidosiren* from America (3) *Protopterus* from Africa.

These dipnoi known for unique respiration behavior because all of these have specialized system for respiration. Dipnoi also consider a rare fish and mostly found in high sea.

Neoceratodus have monopneumona lung means have single lung like structure and this dipnoi also possess gills so *neoceratodus* dipnoi largely depend on respiration under the water by using gills but *lepidosiren* and *protopterus* have dipneumona lung means have two separate lung and these dipnoi largely depend on air breathing instead of gills gas exchange. Even though these all are dipnoi but only *protopterus* is obligate (rely on only one) air breathing dipnoi fish.



(2) Actinopterygii :- Actinopterygii is modern and advanced bony fishes. It is one of the largest and most diverse sub-class of bony fishes, which include several number of order and family. The actinopterygii have ray-finned fishes. These ray fins are flexible and supported by ray of small thin bones. There are following feature of Actinopterygii :-

- (1) Endoskeleton made by bones.
- (2) These fishes possess cycloid, ctenoid and gonoid scales.
- (3) Variety of mouth type are present.
- (4) It's an advanced fishes so found wide range of features.



Trick is below to remember these following orders;

There are following order of Actinopterygii :-

(1) **Syngnathiformes** :- In this order, fishes have elongated snout but small mouth present at end of the elongated snout. These fishes mostly found in marine water and they are scaleless but present bony rings. The Syngnathiformes fishes feeds mostly micro-nutrient including planktons. Example;- sea horse (Hippocampus), sea dragon, pipe fishes etc.

★ Sea horse have prehensile tails (monkey tail), male posses brood pouch for retain egg until hatch. Sea horse fish is the slowest moving fish because it migrate 5m in 1 hour.



(2) **Salmoniformes** :- In Salmoniformes includes salmons and trouts which is type of Anadromous fish means they lives in marine water but for spawning purpose, they migrate to freshwater. While going back to the marine water is very rare because most of the fish dies after spawning and during migration. Snow-trout belongs from cypriniformes. They have very small cycloid scales and mouth is terminal as well as sturdy muscles which is efficient for swimming. In contrast to others salmons have very well developed sensory chemo-reception system for migration that found in olfactory organ and taste bud. Salmon have single dorsal fin and adipose fin. Salmoniformes have deeply forked mouth and have single row of teeth.

(3) **Tetradontiformes** :- The Fish which found in this order is Puffer fish, File fish, Sun fish (Mola mola). Sun fish is the second heaviest bony fish. Note heaviest fish in world is whale shark (Rhincodon typus). As name implies that “Tetra” means four and “Odont” refers teeth and forms is morphology so term Tetradontiformes refers the fish has four teeth, two on upper jaw and two on lower jaw. Out of these, puffer fish is commercially most important fish and it’s a popular food fish in Japan. This puffer fish is the world most toxic fish because it have *neurotoxin* chemical called **Tetradotoxin (TTX)**. This neurotoxin bind to voltage gated sodium channel and prevent the production of action potential therefore person dies but this TTX is incapable to bind on the same channel in puffer fish because this fish has mutant of this channel. Puffer fish has symbiotic bacteria which produce this TTX. Puffer fish and it’s related species have special type of body protection

because they have diverticulum in it's tube of lumen (mostly in stomach). This **diverticulum** get expand during stimulus by taking extra oxygen or water. Even some of the species of puffer fish have sting on outer skin which is also harmful for humans.

(4) **Siluriformes** :- Siluriformes so called catfish are scaleless fish and they are mostly *nocturnal* and have barbels around the mouth and mouth is mostly inferior type. Catfishes are featured for lack of swim bladder, presence of adipose fin, venomous fins. Mostly they lives at bottom and get food from here. Siluriformes are one of the major commercially important fish in west coast of India and north india. Following family and species :-

(a) **Siluridae** :- In this family include helicopter catfish(wallago attu), Ghost glass catfish, Ompok. They all are carnivora which feed mainly small insect, fishes and crustaceans. They have deeply forked mouth with sharp teeth. They have single dorsal fin with spiny anterior but soft ray fin at back. Adipose fin is absent and elongated body.

(b) **Ariidae** :- This family contribute marine catfishes. These fishes has venomous fins.

(c) **Bagridae** :- This family have many commercially important food catfishes. Bagridae fishes have adipose fin as well as venomous pectoral fin with spines. In mystus genus include *mystus gulio* from freshwater and *mystus vittatus* from marine water.

(d) **Clariidae** :- This family has *Clarias batrachus* fish. This fish have long dorsal fin from head to tail with no spine but pectoral fin get attached with venomous sting. The anal fin extended from head to tail as well. Head is compressed with four pair of barbels at mouth. These fishes known for it's gill modification because this catfish can breath out of water so the are called air breathing cat fish. *Clarias batrachus* have labyrinth type of gill modification of primary gill arch therefore it can respire through air.

(e) **Pangasiidae** :- It is the largest sized catfish and mostly called shark catfish due to its appearance and shape. In this family include *pangasianodon hypophthalmus* (Iridescent shark) and others. Most of the species in this family are aquarium fishes and some are commercially important fishes. These fishes are active swimmer and have two pair of barbels.

(f) **Heteropneustidae** :- Singhi fish or heteropneustes fossilis is member of this family and known for venomous sting which present on pectoral fins. These fishes have small dorsal fin but long anal fin. They have highly venomous pectoral fin. Anal fin is long and head is compressed and have thick barbels. Singhi fish are carnivora fish.

(g) **Loricariidae** :- In this family present one of the sucker mouth catfish called sucker catfish. This fish have bony plate on skin with black and white colour. This sucker catfish have specialized mouth by which it sucks and feeds.

(5) **Perciformes** :- This is the order of perch like body form fishes. In this order include sunfish of freshwater(don't confuse with sunfish of ocean), bass etc. Indeed this order modified in special clade called percomorpha. Percomorpha have several orders and family of fishes like

Salmoniformes, cichliformes, clupiformes etc. These fishes have ctenoid scales on their body. fish is that it have long dorsal fin with anterior part spiny but posterior part soft ray-finned fish.

(6) **Mugiliformes** :- Mugiliformes fishes are mostly marine fishes with elongated body. These fishes are featured for Ctenoid scales (also posses cycloid scale), Blunt head and Active swimmer. They are omnivorous but some species in this order shows herbivorous. mullet is major fish in this order. They have double dorsal fin where first is spiny and second is soft .

This mullets are also characterized for have unique behavior that it leap out of water for some time period during swimming. Scientist research says that this process of behavior is due to two reason because (1) For getting enough oxygen (2) Escaping from prey. One of the known species is *mugli cephalus*.

(7) **Channiformes** :- Channiformes also known as snake-head catfish due to it's snake like head. Channiformes have long dorsal fin with circular caudal fin and have cycloid scales on body. Notable feature of this fish is that it have pharynx air sac for breathing. This pharynx air sac is important for aerial respiration. It can survive 4 days out of water but the condition is body should be saturated by water. Even this Channa genus fishes can crawl 400m on mud or wet land. *channa striata* and *channa punctatus* are a freshwater fish.

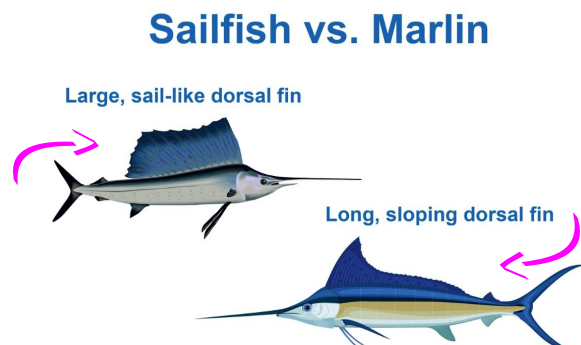
(8) **Scombriformes** :- Tuna and mackerel is the major fish of this order. Both of these fishes come from scombridae family but this family divided into two group for tuna and mackerel separately.

Tuna fish included in thunnus and neothunnus genus, where thunnus genus have blue fin tuna while neothunnus have yellow fin tuna. Tuna is extremely sturdy and active marine water fish. However tuna is Endothermic fish but poikilothermic . Due to presence of large myoglobin tuna muscles is reddish in colour. This feature help in active power of muscles by carrying oxygen quickly to the body muscles for energy. Tun is active swimmer fish so they use Ram ventilation process of respiration. Tuna fish have double dorsal fin with first spiny and hard but posterior is soft one. Between caudal fin and dorsal fin present some small fin-lets which help in stopping and turning of the fish.

	Poikilotherms: Temperature varies with external temperature	Homeotherms: Regulate body temperature so it doesn't vary as much as external temperature
Ectotherms: Most metabolic heat is rapidly lost to the environment; body temperature matches external temperature	Invertebrates, most fishes, and marine reptiles	None
Endotherms: Retain significant metabolic heat; internal temperature stays warmer than external temperature	Some large sharks, tunas, and billfishes	Mammals and birds

Mackerel fish included in two genus (1) Scomber (2) Rastrelliger. *Rastrelliger kanagurta* is the **indian mackerel which is the national fish of india**. Mostly all character and feature of mackerel similar with tuna. Unlike tuna mackerel body is shorter and elongated.

(9) **Istiophoriformes** :- In istiophoridae family contain sailfish and marlin fish. These fishes known for its speed and mostly these are marine fishes. Sail fish is the fastest fish which having 110km/h. but one of the single species of marlin have 130km/h and due to average species in sail fish group have 110km/h that's why sailfish called fastest fish instead of marlin.



(10) **Anabantiformes** :- This order have included mostly aquarium fishes like Betta fish, Gaurami (kissing fish). These fishes have perch like body form and belongs from percomorpha clade. Mostly these anabantiformes fishes are coloured fishes and used for aquarium purpose.

One of the feature of these fishes are that they have labyrinth organ for accessory respiratory organ. Therefore they can survive out of water for a period of time. Betta fish or fighting fish so called because they always fight each other with same sex. For example if you kept these fishes in your aquarium you will notice that they always fights each other. One or both fish will die because they fight for place, food or for everything.

(11) **Polynemiformes** :- The family polynemidae fishes called thread fin fish because they have additional type of pectoral fin beneath the first normal one. Additional type of pectoral fin have filamentous thread like structure which is much long as body. They are mostly omnivorous fishes and have double dorsal fin. In which contain Polynemus paradiseus (Mango fish), Eleutheronema tetradactylum, polynemus indicus etc. These fishes are able to maintain school through well developed lateral line and they has generally elongated body and forked caudal fin.

(12) **Cypriniformes** :- It is one of the major order of commercially important fish because it include all carps and barbs, minnows and loach. This order have following feature :-

- (a) Pharyngeal teeth are present instead of having teeth on jaw.
- (b) Body is covered with cycloid scales.
- (c) Long but single dorsal fin is present.
- (d) Feeding habits varies with species to species.
- (e) Head is lack of scales.

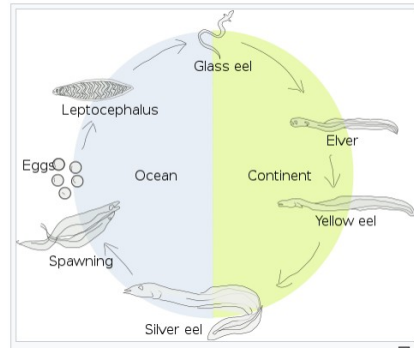
In this order have family cyprinidae :- *catla catla* (catla), *labeo rohita* (Rohu), *Cyprinus carpio* (Common carp), *Cirrhinus mrigala*, *Ctenopharyngodon idella* (Grass carp), *Hypophthalmichthys molitrix* (silver carp), **Goldfish** (*Carassius auratus*), minnows, snow trout and koi etc.

(13) **Clupiformes** :- Clupiformes fishes are known for having pneumatic duct which connects swim bladder to alimentary canal. These fishes have only one dorsal fin and body covered with cycloid scales type. The clupiformes fishes are mostly streamlined body and white coloured at ventral than dorsal side. Most of theses fishes are found in marine environment and well known for schooling behavior. In this order included; herring fish, sardines fish, hilsa, anchovies etc. These fishes are found in two important family— Clupeidae (herrings, sardines and hilsa) and Engraulidae (Anchovies).

(14) **Gonorrhynchiformes** :- The family Chanidae includes Milk fish, have single dorsal fin and cycloid scales with elongated body and streamline body. The milk fish is the major fish in this order which found in both freshwater and marine but mostly it dominant in marine water. Milk fish (*Chanos chanos*) is one of the active swimmer which also known for maintaining school while swimming.

(15) **Anguilliformes** :- Eel is this major fish of this order. Eel is know for having elongated body with elongated dorsal fin from trunk of the body to the caudal fin. *Anguilla anguilla* and *Electrophorus electricus* (electric Eel) are best known eel fish. Eel are Catadromous fish which means they live in freshwater but migrate to marine water for spawning but very less number of fishes come back to freshwater after spawning. They have extremely elongated body with small pectoral fin but long dorsal and anal fin which fused at tail region therefore they have pointed caudal fin.

One of the electrical *Electrophorus electricus* which so called because of producing electric current by electrocyte cell in the body. The current voltage depend on type of species, electrocyte cell are modified skeleton muscle cell which capable of producing voltages.



(16) **Cichliformes** :- In this order include economically important Tilapia and Oscar fish from Cichlidae family. Some of the fishes are aquarium fish from this order as well as economical important fishes like tilapia. Blue Tilapia (*Oreochromis niloticus*) and red Tilapia (*Oreochromis mossambicus*) are commercially important fishes. They possess cycloid scales with single dorsal fin but long which generally included in percomorpha clade therefore it have anterior spiny and posterior ray-fin. They are perch like fish.



TRICK TO REMEMBER THESE ORDERS :-

syn-salmo-tetra-sil-per-mug-chann-scomb-istio-anab, poly-cy-gonna-angul-clu-cich.

Identification of commercially important species of prawn, crabs, lobster, bivalves, gastropods and cephalopods of India.

(1) prawn / shrimp :- prawn is aquatic invertebrate organism that means they lack vertebral column or backbone which belongs from phylum Arthropod. Prawn or shrimp are class of Crustacea and order of decapoda means they have ten legs or 5 pair of appendages but Research experiments suggest that they have 13 legs because of addition of antennae. There are following species from family Palaemonidae:-

- (a) White prawn :- *Penaeus indicus*
- (b) Tiger prawn :- *Penaeus monodon*
- (c) Giant prawn :- *Macrobrachium rosenbergii*

Sometime it's confusing term between prawn and shrimp but major study says that generally both term used together but it have some major morphological difference is following ;-

- (a) Prawn is generally greater in size than shrimp.
- (b) Prawn is somewhat straight but shrimp is curled.
- (c) Prawn is mostly belongs from freshwater but shrimp are mariner.

Prawn is invertebrate so they don't have vertebral column, Therefore prawn or shrimp is **not** a fish. Prawns are mostly swim (crawl) during night time called nocturnal. Prawn are omnivorous organism mainly feeds; plankton, grasses, insects and small larvae. Prawn are bottom crawler hence caught by gill net.

Characters :- Prawns are decapoda so they have ten legs or appendages. Each leg has two branches with tiny rough surface, called biramous leg. Species of prawns have two prominent leg ate anterior, called claws. Rest of 8 leg are further divided into two par (1) Chelated leg (2) Non-chelated leg . Chelated leg so called walking leg which is 5 in number BUT Non-chelated leg are called swimming leg which is 3 in number. Prawn body is segmented body into 6 compartment. Each compartment of segmentation consist two branched leg. Last end or tail region have unique structure called Uropod. A single Telson surrounded by pair of uropod.

There are two separate part of prawn body (a) Cephalothorax and (b) Abdomen .

Cephalothorax have consist following parts :-

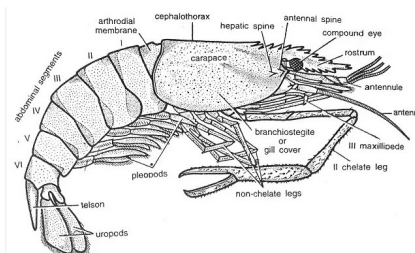
- (a) Mouth :- A small mouth present around antenna.
- (b) Rostrum :- Elongated snout like structure above the mouth .
- (c) Antenna :- There is two pair of antenna are present. One pair is smaller than other pair of antenna .
- (d) Carapace :- It's a external cover around the head region. Because gill is situated withing this carapace so it forms small opening for respiration. Carapace made of chitin and collagen. Inside the carapace there are several vital organs are arranged for their function, like ; heart, gills, brain etc.
- (e) Claws :- A prominent leg for getting food and protection against prey.
- (f) Eye :- Pair of stalked eye are present on both side of the body.

Abdomen have following parts :-

- (a) Segmentation :- There are 6 segmentation of the abdomen in prawns. Each segmented compartment attached with each other by bonding compound which is secreted by layer of skin .

(b) Tail :- In which Consist uropod and telson.

(c) Abdominal cavity :- in female prawn, brood pouch is larger than male one for retaining of her eggs.



Physiological system :- Physiology start with digestive system. There are three part of prawn digestive system (1) Fore gut :- In this section consist mouth, Esophagus and early part of stomach. Mouth receives food by claws and move to esophagus. (2) Mid gut :- In this segment consist stomach, Intestine and some symbiotic algae which produce digestive juice. In Mid gut occurs complete digestion of food. (3) Hind gut :- Consist rectum and anus. These removes wastes from the digestive system.

Respiration is occurs through pair of Gill. Each pair gills consist several gill arch with gill filament which is small in size. Prawn get oxygen by counter exchange process from dissolved oxygen in water. This mechanism involves creating internal pressure on gill for exchange of oxygen and CO₂. Open type of Circulatory system consist heart and blue coloured blood because of Hemocyanin (Hemocyanin is type of metaloprotein which have copper). In Prawn oxygenated blood is blue coloured because of hemocynine. The prawn heart is triangular with sharp end at head region and flat region at tail. Prawn reproduce externally by their reproductive organ.

There are following phase of development in prawn:- Egg—Larvae—Zoea—Mysis—Juvenile. There are total 11 stage of development takes place in 30 to 50 days.

At larval stage prawns act like carnivora type of feeding and feed mostly zooplankton because zooplankton easy to digest but after post juvenile stage they prefer omnivorous behavior.

(2) Crab :- Crab is aquatic invertebrate organism. Crab are class of crustacea and order of decapoda means they have ten legs or 5 pair of appendages. Almost all feature and physiology is similar as prawn.

There are following species :-

(a) Mud crab :- *Scylla serrata* (Belongs from **Portunidae** family)

(b) *Varuna litterata* (**Grapsidae** family)

crabs are also nocturnal and mostly crawl on water sediment. crabs are omnivorous organism mainly feed ; planktons, grasses, insects and small larvae of fishes and other invertebrates. Crabs are bottom crawler hence caught by gill net and traps.

Characters :- Crab is decapoda so they have ten leg or appendages. Crabs are characterized for having two prominent and larger leg called claws. These claws help to capture and taking the food. Rest of 8 leg are further divided into two part (1) Chelated leg (2) Non-chelated leg. Chelated leg are called walking leg which are 6 in number BUT Non-chelated leg are called swimming leg which are 2 in number. Unlike prawn, Crab haven't segmented body, tail, rostrum (It is an raised pointed extension of skull and carapace) and antenna. There are two separate part of crab body (a) Cephalothorax (b) Abdomen. Unlike prawn, In crab the abdomen present at lower to cephalothorax but in prawn abdomen at back of cephalothorax.

Cephalothorax have consist following parts :-

(a) Mouth :- A small mouth which projecting ventral side.

(b) Carapace :- it's a external covering on dorsal side of the crabs. Carapace form small opening for gill chamber. Carapace made of chitin and collagen. Inside the carapace present several vital organs which are arranged for their function ; like heart, gills, brain etc.

(c) Claws :- Two prominent leg which are very larger than other appendages, generally use for capture the prey.

(d) Eye :- Pair of stalked eye are present. Unlike prawn, Crab have stalked gap for adjusting their eyes.

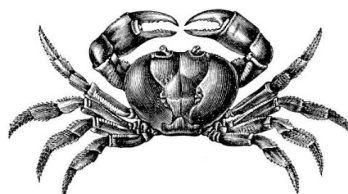
Abdomen have following parts :-

(a) Brood pouch :- In female crab, brood pouch and abdominal region is larger and wider than male but male have longer leg than female.

(b) Appendages are present.

Physiological system :- Physiology system includes digestive system, circulatory system, respiratory system and so on. There are three part of crab digestive system (1) Fore gut :- In this section consist mouth, esophagus and early part of stomach. Mouth receives food by Claws. (2) Mid gut :- In this consist stomach, intestine and some symbiotic algae which produce digestive juice. In mid gut occurs complete digestion of food. (3) Hind gut :- Consist rectum and anus. Some of the waste remove by green gland present at mouth.

Respiration is occurs through pair of gill on either side of the body within carapace. Gills have consist Gill arch with gill filament. Open type of Circulatory system consist heart and blood. Crab oxygenated blood is blue coloured because of hemocynine. Crab reproduce externally so called External fertilization.



(3) Lobster :- Lobster is invertebrate animal of class crustacea and order decapoda. It is similar to prawn because most of the character similar to it. One of the family of lobster is Palinuridae. Lobster is colourful marine organism which mostly caught for delicious sea food. There are following species from Arthropods phylum:-

(a) Spiny lobster :- *Panulirus homarus*

(b) Rock lobster :- *Panulirus ornatus* .

Lobster are omnivorous and nocturnal (Night mover) organism which found in marine water at sediment region. Lobster are omnivorous so it feeds planktons, small insects and fishes and also eat other larvae of invertebrates. Because Lobster are decapoda hence it have ten appendages or legs. Unlike prawn, lobster have two very large prominent leg which help in crashing and finding of prey. Rest of leg are help in walking (6 legs) and swimming (2 leg). External hard structure made by chitin called carapace. They have two pair of prominent antenna. lobster body is segmented body into 6 compartment. Each compartment of segmentation consist two branched leg. Last end or tail region have unique structure called uropod. A single telson surrounded by pair of uropod on either side. Lobster uropod is more flat and broad in size than prawns.

There is two separate part of prawn body (a) cephalothorax and (b) Abdomen .

Cephalothorax have consist following parts :-

(a) Mouth :- A small mouth present around antenna which ventrally located.

(b) Rostrum :- It's a elongated snout or portion of carapace which is part of head region.

(c) Antenna :- Two pair of antennae are present in lobster where two are larger than other one.

(d) Carapace :- It's a external covering around the head region which covers the different visceral organ of lobster. It's a chitinous and collagen rich structure that function as external protective coat of lobster.

(e) Claws :- There are two claws which are very larger than other appendages and this claws generally used for protection, food crushing and capturing.

(f) Eye :- Pair of stalked eye are present on either side of the body.

Abdomen have following parts :-

(a) Segmentation :- There are 6 segmentation of the abdomen have found in lobster. Each segmented compartment attached with each other which allows to bend the body of lobster.

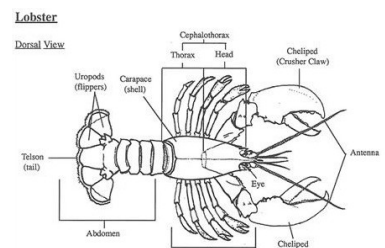
(b) Tail :- In lobster, two pair of uropod are surrounds one single telson.

(c) Abdominal cavity:- In female lobster, Brood pouch is larger than male one. This cavity used by lobster for retention of her egg until egg matures.

Physiological system :- There are three part of lobster digestive system (1) Fore gut :- In this section consist mouth , esophagus and early part of stomach. Mouth get it's food by claws and move to esophagus (2) Mid gut :- In this consist stomach, Intestine and some symbiotic algae which produce digestive juice. In mid gut occurs complete digestion of food. (3) Hind gut :- Consist rectum and anus. These remove waste of body.

Respiration is occurs through pair of gill. Each pair consist seven to six number of gill arch with gill filament. Lobster get oxygen by counter exchange process. Circulatory system consist heart and arteries and blood . Lobster oxygenated blood is blue due to hemocyanin.

At larvae stage lobster prefer carnivora type of feeding and feed mostly zooplankton because zooplankton easy to digest but after larvae stage or means at post juvenile stage they prefer omnivorous behavior .



(4) Bivalves :- Bivalves are Invertebrate organism of phylum Mollusca and Class Bivalvia.

Bivalves are Bilaterally symmetric organism. As name implies the Bivalves has two valves which attached together by ligament at one point called Hinge. In bivalvia consist Mussels, Oyster and Clams.

(a) pacific oyster

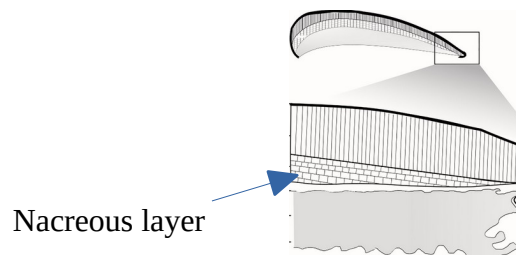
(b) blue mussels

(c) Giant clam

Bivalvia are very divers class with different species. Some of the bivalvia known for their delicious taste while some are known for producing pearls. Most of the Edible bivalvia are found in clams. Oyster are commonly found in marine and all of it's species produce pearls Where Mussels are found in marine and freshwater both which also produce the pearl but less than oyster. Mussels, oyster and clams are belongs to same phylum but have different structure and appearance like ; Mussels generally black and smooth shell with small in size than oyster while oyster have rough shell and whitish coloration. Clams are rounded and varies in shapes.

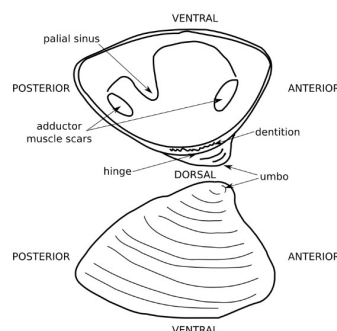
Character :- Bivalves are made of three layer of shell (1) Outer layer:- Chitin and calcium carbonate with colour cells. (2) middle layer:- calcium carbonate.(3) Nacreous or inner layer:- plates of calcium carbonate and chitin and protein matrix which fills them. Nacreous layer is iridescent layer. Bivalvia have two valves both attached to each other at hinge by ligament. Umbo is

the oldest part present above the hinge. On the basis of species there are several number of structure of hinge. Inside the valve, Mantle is epithelium tissue on nacreous layer. Mantle is shiny, smooth and thin tissue which produce calcium carbonate and function as covering visceral organs. Mantle also covers the process of pearls by nacre. Two strong muscles which connect the both valves is called adductor muscles scar. At edge region of mantle forms a tubular structure which called as **siphon or funnel**. Siphon is directly opens on gills for respiration. There are two siphon one is ex-current and another is in-current. Bivalvia are omnivorous, Feeds plankton and zooplankton and also sands. The pearl is formed by calcium carbonate (Aragonite), organic matrix like protein and chitin etc. When the irritating substance like sand, parasite, dust and microorganism enters onto the mantle of bivalves, the mantle start covering them and transport to the nacre face. Once the irritating substance being trapped between nacreous layer and mantle tissue, the mantle secrete nacre layer around them to form pearl.



Physiology of Bivalvia :- Bivalvia have small intestine and digestive tract which feeds by filter feeding. Digestive system of bivalve has simple organization which collect food particle from water which come from siphon. Most of the bivalvia feed sand and mud. Complete digestion of food occurs in mid gut of bivalvia.

Respiration is occurs through ctenidia or kind of gills. Bivalvia gills not only used to respire but also for filtering of food in water. For this purpose the water enters into the cavity by siphon and also extruded from second siphon. Bivalvia has simple organization of brain which even capable for different physiological and some protective mechanism like pearl formation. Bivalvia has open type of circulatory system which posses usually blue colour due to hemocyanin. Reproduction in bivalvia is through sexual and Hermaphroditism reproduction.



(5) Gastropods :- Gastropods are invertebrate of phylum mollusca and class gastropod. This class has consist snail and slug. Usually the term Slug is without exoskeleton but snail have exoskeleton

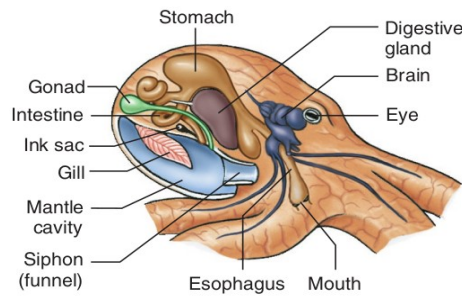
made of calcium carbonate on outer covering of body. These animal have two or four antenna which generally found in slug. Slug have better adaptation for land while snail lives under the water or some time on muddy land.

Both snail and slug have muscular foot which ultimately join ot internal visceral organs like digestive system. The snail have outer cage made of calcium carbonate. The snail also posses one operaculum which close or open the shell through which the internal foot comes out side. Gastropods are mostly sand feeder and grasses feeder. This organism have very simple digestive system and circulatory system like other mollusca. Reproduction is occurs through gamete fusion in water from male and female gastropods.

(6) Cephalopods :- Cephalopods are molluscan found in marine water. As name implies they have foot on head called “head footed”. In class Cephalopods consist well developed molluscan like Octopus, squid, cuttlefish and nautilus are major organism of this class. Phylum mollusca has class Cephalopoda.

Two sub-class Coleoidae includes octopus, squid and cuttlefish but Nautilus included in sub-class Nautiloidea. Cephalopods are exclusively marine but some of the species found in brackish water. Only nautilus have external shell which is made of calcium carbonate. Cephalopods have unique eyes but nautilus have crossed eyes by which water can enter and move out. Cephalopods have bioluminescence system. It has small mouth surrounded by arms or tentacles. Cephalopods are omnivorous animal which feed crustaceans, algae, fish larvae and zooplankton. Squid and cuttlefish have ten appendage where Two appendage are prominent called tentacles. Tentacles have sucker structure while other eight appendage are called arms. These arms help in capture the food. Nautilus have above 30 appendages. Octopus are known for because it have 8 arms but no tentacles because these arms have modified sucker which help in capture the food.

Cephalopods are active swimmer but octopus are relatively slower one because, Octopus internal cavity muscles made by simple muscular structure but squid internal muscles made by collagen and collagen can sustain long time movement and contraction. Cephalopods move by **jet propulsion** mechanism. Jet propulsion system is highly energy consuming process so octopus mostly use crawling by their arms instead of swimming by jet propulsion. In jet propulsion water enter inside the muscular body by opening called siphon or funnel and this water forcefully eject out of the body. Cephalopods also known for it's ink secreting feature. Ink of cephalopods contain in ink sac which lies at intestine. During stimulus of prey or in condition of protection it contract their ink sac therefore ink get ejected by duct through siphon. In ink consist melanin pigment and tyrosinase therefore it's colour is black and blue. This ink consist tyrosinase which can cause blindness of person and organism. Ink release out with mucus that's help in forming cloud in water body.



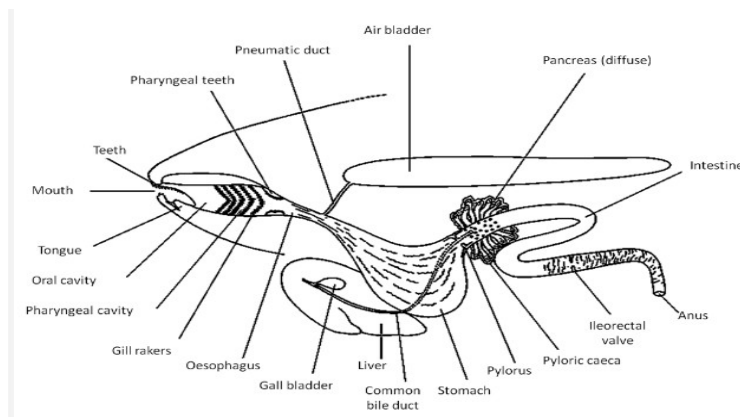
In cephalopods respiration is very unique because respiration and jet propulsion used together. When it take water by siphon for respiration then it create strong flow of water inside the siphon cavity which forcefully crosses the gills. This strong flow of water on gills cause respiration by counter exchange process. After respiration, the water in siphon cavity now ready to eject out of the body by siphon with high force and therefore it pushes the organism in further direction.

cephalopods have three part of digestive system. It consist fore gut, mid gut and hind gut. Cephalopods have much developed brain than other invertebrate and capable for different complex mechanism.

Blood of cephalopods is blue due to hemocyanin pigment. This hemocyanin have lower ability to carry oxygen than hemoglobin. Reproduction of cephalopods occurs through external and internal both depends on species. Sperm of cephalopods is called hectocotylus which fertilized egg of female cephalopods.

Fish alimentary canal and associated structures

Fish alimentary canal or fish digestive system is one of the important fish physiological system. The digestion the process of converting macro-molecule or polymer into micro-molecule or monomer. It consist mouth, buccopharynx, esophagus, stomach, intestine, rectum and anus. The fish digestive system or alimentary canal is varied according to species because some fish posses stomach while other don't and some have long tract but others have small. Fish digestive system start with mouth and end at anus but mid between these system present different associated structure like liver, pancreas, gall bladder etc. let's start fish digestive system; here we are taking general digestive system which apply to all fishes.



All fish eat food by mouth which is the first part of digestive system. On the basis of species there are several type of mouth which adopted according to it's habits and genetics. Mouth of fishes help to convert food into smaller one. Mouth is featured with teeth but some fishes have no teeth on jaw instead they posses pharyngeal teeth. Mouth contained different cell which secrete enzyme which combine with particles of food while crunching. Major enzyme are amylase and mucus.

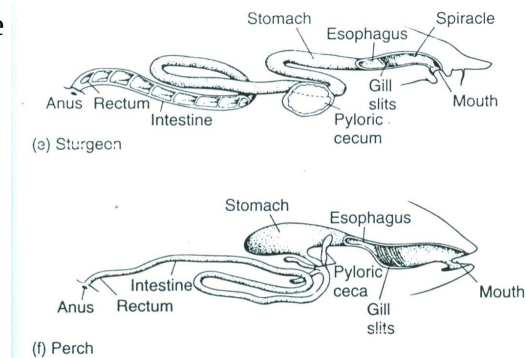
After chewing the food, It moves to further system called buccopharynx and buccal cavity between mouth and esophagus. It is part of mouth which present at gills region. There is a sphincter which allow to move food inside the esophagus lumen. Fish esophagus is small which length depends on fish species. Esophagus is a tubular muscular structure which used to propel the crunched food by process called peristaltic movement. This process of peristaltic movement occurs by nerves plexus which present in different layer of GI tract.

The digestive system or the alimentary canal of fish is made by different layer one by one. The Innermost layer of GI of fish is **mucosa** which has also three layer (1) Mucous membrane :- this membrane is made of epithelial cell. It help in secretion of mucus, GI enzymes and also absorption of nutrient. (2) Lamina propria:- it is second layer of mucosa which has immune function and also it's a structural supportive mechanism. (3) Muscularis mucosa :- it's a inner layer of mucosa which help in contraction and relaxation of tract. The Second layer of GI of fish is **Sub-mucosa** which have associated function with mucosa layer. Sub-mucosa has blood vessels and nerves. Third layer is **muscularis externa**. It is most important layer because it is actual site for peristalsis by smooth muscles. Muscularis externa consider to be outer most layer of GI of alimentary canal of fish. In some fishes the external layer of GI tract is serosa. Through these layer of GI tube, the mixing and propulsive mechanism of food occurs.

Some fishes do not have stomach like gold fish. In these fishes the esophagus direct connected with intestine. The shape of stomach varies species to species. The stomach of fish is most valuable organ because the mucosa membrane cell secrete different digestive enzyme like hydrochloric acid and proteolytic enzyme for protein digestion. The stomach is site of temporarily storage and mixing of food to form chyme in fishes. The stomach itself protected from hydrochloric acid by mucous and bicarbonate. There are Cells distributed in mucosa layer which is made by two part of cells called (1) parietal cell (2) chief cell. Parietal cell secrete hydrochloric acid and chief cell secrete pepsin, mucous and bicarbonate. There are pyloric caeca at entrance of intestine but it consider the part of stomach which increases the surface area for digestion and action of enzymes. These caeca are outgrowth of mucosa layer of GI tract.



Fish intestine length varies accordingly to species. The intestine may directed from esophagus in those fishes which have no stomach. Fish intestine have different region; Anterior (duodenum), middle (jejunum) and posterior (ilium). Rectum in fishes is also the part of fish intestine. Last part of fish stomach is attached with duodenum of intestine. The fish intestine is the muscular structure where most of the food digested by secretion of digestive juice with help of mechanical mixing. At duodenum site pancreas is connected for secretion of different digestive juice like trypsin, carboxypeptidase, glycosydase etc. Bile is formed in liver but stored in gall bladder which secrete for digestion of planktons and lipid compound. Pancreas secrete digestive juice by Acinar cell found in pancreas. Intestine have extremely tiny structure on lumen part called villi and microvilli. The intestine has variable length regarding to species. Intestine of fish is the main part of absorption of food. The size of intestine is vary according to fish species because carnivora fish have small while herbivore fish have long intestine with coiled structure. After absorption and digestion of food, it move to rectum then finally leave from the fish digestive system by Anus.



The fish associated structure with digestive system are liver, pancreas and gall bladder. Liver of fish is reddish-brown coloured organ which usually located in ventral side of fish body. The main important function fish liver is formation of different compound of fatty acid including cholesterol, omega-3 fatty acid, steroid hormones vitamins-A & D and bile acid.

Gills & Respiratory System of Fish

Respiratory system or gas exchange in fishes is very unique because this system involves the gills through which the respiration occurs in fishes. Animal have variety of respiratory organs by which they respire and exchange oxygen and carbon dioxide. In fishes have several respiratory organs including gills, skin, pharyngeal sac, labyrinth organ and gut lining. The primary respiratory organ of fish is gills. Fish respiration or gas exchange occurs through paired of gills which present on either side of the fish head region. The position, shape, size and number of gills depend on fish species. Both pair of gills present at pharynx region of fish. Bony fishes have external covering of gills called operaculum but in elasmobranchii haven't any external operaculum instead elasmobranchii posses gill slits which serves as covering of it.

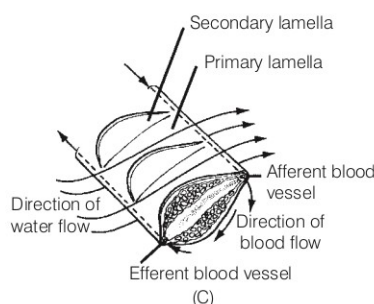
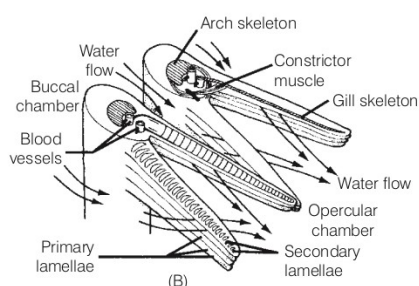
Gills of fish is very efficient for extracting oxygen from water. Fish gills can extract 80 percent of oxygen from water by counter exchange process which describe later. Fish gill is being able to extract oxygen from water are dissolve oxygen because as you know that there are two type of oxygen can be presented in water; bound oxygen with hydrogen to form water molecule and second is free dissolved oxygen among those water molecule. Fish gills consist Gill arch, Gill filament, Primary gill lamellae and Secondary gill lamellae. Due to very high surface area of gill, Fish extract oxygen easily. Lamellae

portion of gill is made by epithelium layer. Each lamellae has layer of epithelium cell which has blood capillaries through which it take oxygen and releases carbon dioxide.

(1) Gills arch :- Gill arch is muscular, fleshy structure which generally white in colour. It is supportive portion of gills through which gills performs it's function easily. There is two side portion of the gill arch, One portion has Gills rakers while other side has gill filament. Gill rakers is not a part of fish respiration because it help in filtration of food from water. In contrast, gill filament have different units of respiration. The number of gill arch can vary accordingly with species because bony fishes posses usually five pair of gill arch but on other hand elasmobranchii have five to six. Fish ventral aorta of the heart branched into afferent artery which enters into gill arch and where it form capillaries for gas exchange. The Efferent artery which carry oxygenated blood and leave from gill.

(2) Gill filament :- In general, there two OR a pair of gill filament on each gill arch. Each gill filament attached with gill arch via composition of collagen and muscles. The number of gills filament varies according to species to species. Those fishes which have only single gill filament on of gill arch called hemibranch gills but Those fishes who have two gill filament on gill arch is called holobranch gill. Gill filament bears several gill lamellae which are sit of counter exchange of gases.

(3) Primary Gill lamellae :- Primary gill lamellae is flat out growth from gill arch which makes gill filament. It is made of epithelium layer and mostly red in colour. Primary gill lamellae is plate like structure that has many capillaries for gas exchange. There are several number of primary gill lamellae, are attached to gill arch and ultimately form gill filament.

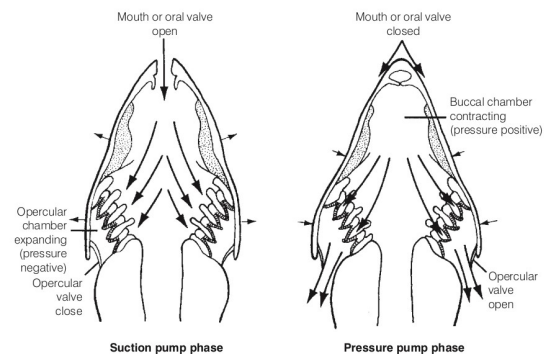


(4) secondary gill lamellae :- Secondary gill lamellae or simple lamellae is the unit of gas exchange. It is made of epithelium layer that featured for having very thin blood capillaries. The secondary gill lamellae increases the surface area fro respiration. This lamellae is present on both side of flattened primary gill lamellae. At base site of secondary lamellae (attached to primary lamellae) present a cell which responsible for ion exchange called chloride cell. The secondary gill lamellae is also flat structure of epithelial cell layer.

The process of gas exchange occurs in this way:- First, water taken from mouth for respiration is depend on species because two type of process is found. (1) **Ram ventilation process** is the mechanism by which the fish like shark and tuna open their mouth continuously therefore the water rapidly flows the gill lamellae and due to counter exchange the respiration occurs. In this process

fish must be active swimmer because when they actively move so water forcefully across the gill lamellae and gas exchange occurs due to movement of water. But in most of other fishes have specialized mechanism of pressure gradients counter exchange. In this mechanism fishes use their lips and mouth cavity for creating water pressure and forcefully blows on gills. Well the formation of water pressure in mouth cavity is highly specialized because at this time operaculum must be close and opens gradually when water pushes on gill. Capillaries present in gill lamellae extract oxygen from water by simple diffusion / active transport.

In case of marine water fishes, it uses active transport for getting oxygen. Carbon dioxide readily released into the water because CO₂ have more solubility with water than oxygen. The process of extracting oxygen from water is through counter current exchange / counter exchange process. After this process oxygen carried by hemoglobin present in blood and blood become oxygenated. Now oxygenated blood move with efferent artery toward dorsal arteriole and finally distributed to body.



Pseudobranch gills is reduced gill and almost non-functional in fishes while in elasmobranchii the spiracles open in Pseudobranch region. It suggest that it is functional in embryonic stages but after metamorphosis this gill become reduced. The Pseudobranch gill receive oxygenated blood, function as sensory receptor for molecule and secretion of mucus. This Pseudobranch present mostly at anterior of the gills.

Swim bladder / Air bladder

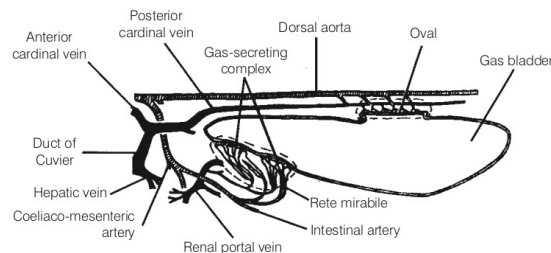
Swim bladder or air bladder and sometime gas bladder is important organ present in fishes. It lies on dorsal position of the body near to kidney but the actual position and shape can vary among the fish species. It is white coloured pouch/sac structure that help in different function like lung, producing sound, buoyancy and storing oxygen, carbon dioxide and nitrogen.

The swim bladder either have single chamber or double chamber depend on type of the fish but most of the fishes have double chambered swim bladder where one is smaller than other one. The swim bladder has contain guanine crystal which make it impermeable to to gases but also the membrane of swim bladder is made by epithelial cell (mucosa layer), connective tissue and type of smooth muscle called sonic smooth muscle cell. Blood capillaries and gas glands are distributed on layer of this bladder.

The main function of swim bladder is to provide buoyancy to the fish but most of the fishes like catfishes, elasmobranchii and others don't have swim bladder instead, buoyancy provided by oil in liver. Swim bladder also produce sound for communicating with each other or during finding prey. This sound generated by contracting sonic muscles which present in membrane of bladder. The sound is in the form of wave like pattern which easily identified by fishes. Another

function of swim bladder is that it act like lung because in sense of respiration it used to oxygenation of the blood. It is not a lung but it act like lung functions.

Some fishes have direct connection of swim bladder to digestive tract by a duct called **pneumatic duct**. The pneumatic duct if present in fish, then always linked to larger chambered swim bladder. Those fishes which have pneumatic duct connection between swim bladder and lumen of esophagus called **physostomous fish** but those who have not present pneumatic duct called **physoclistous fish**. During embryonic development this pneumatic duct appear in both type of fishes but after metamorphosis this pneumatic duct disappear in physoclistous fish. Physostomous fishes fills their bladder by taking air from mouth or esophagus but in physoclistous fish they don't have any additional duct so these fishes fills their bladder by gas gland present on membrane of swim bladder by taking gases from blood composition like oxygen, CO₂ etc. .



Swim bladder membrane is made by epithelial and sonic muscles cell. This sonic muscles cell known for fast contraction and relaxation. Additionally, there are different other gland and capillaries attached with swim bladder by which it oxygenate the blood and also extract wastes gases. The gas gland predominantly found on layer of swim bladder in physoclistous fish than physostomous fishes because reason is that in pneumatic duct bearer fishes have very less role of these gland and these physostomous fishes can take enough gases from this duct. There are different capillaries attached with bladder membrane for filling and emptying them. Physoclistous fishes fill their bladder by secreting lactic acid in the blood stream by gas gland, this lactic acid cause counter current exchange of the oxygen, carbon dioxide and nitrogen into bladder. In case of physostomous fishes, they have pneumatic duct which is mainly connected with larger chamber of swim bladder. Due to this duct swim bladder readily get filled by taking air from mouth. The lactic acid cause acidification of blood which decreases the affinity of oxygen for hemoglobin and therefore the oxygen diffuse into the swim bladder. When oxygen needed to transport to the body, the oxygen diffuses back into blood stream and carbon dioxide into swim bladder.

The use of swim bladder is very unique because most of the wine and alcohol clarify by using this swim bladder. Swim bladder used to form isinglass which used for clarification of alcohols. The membrane of swim bladder consist of three layer (1) mucosa layer which made by three layer namely; epithelium, lamina propria, muscularis mucosa. (2) sub-mucous (3) muscle cell.

Accessory respiratory organs

Accessory respiratory organ is additional organ for respiration which helps in respiration and supply enough oxygen to body. The accessory respiratory organs mostly found in freshwater fishes but rarely in marine because it suggest that oxygen concentration in marine water is generally high so marine fishes largely depend on their gill and marine fishes gill are also very efficient for extracting oxygen from water. Several different organ use for accessory respiration by fishes. There are following accessory organs used for respiration :-

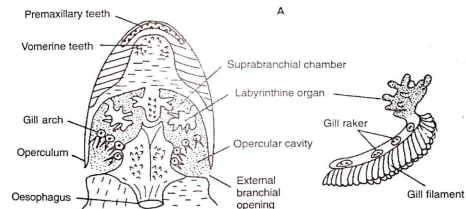
(1) swim bladder :- The Air bladder or swim bladder has many function including buoyancy, sound wave production, act like lung and so fourth but one of the important function of air bladder is that it behaves like lung in Dipnoi fishes for example lepidosiren, neoceratodus and protopterus. Air bladder also function for respiration in lower osteichthyes. In dipnoi fishes the air bladder completely modified into lung and even two genus protopterus and lepidosiren are depend on aerial respiration by using air bladder or modified lung. The air bladder which changed into the lung has relation with amphibians lung. Because of epithelial respiratory lining on the wall of these organs made possible for gas exchange easily by simple diffusion and partial pressure of particular gas.

(2) Skin :- Skin of the fish is able to extract oxygen because semi-permeable layer make this possible in some fish of skin for accessory respiratory organ. In these fishes like eel (*Anguilla anguilla*) have highly vascularized blood vessels in skin. For example Eel fish use skin as Accessory respiratory organ where the skin is very permeable for these gases and able to exchange. These fishes are capable of extracting oxygen from water or air. The moist skin is required for respiration because there are many mucus secreting cells and others are epithelial cell. These mucus makes layer onto the epithelial cell layer and therefore the gases like oxygen can diffuse to it and ultimately crosses the plasma membrane of epithelial cell and oxygenate the blood. Similarly the carbon dioxide removed from the blood either by gills or in similar way through which oxygen entered.

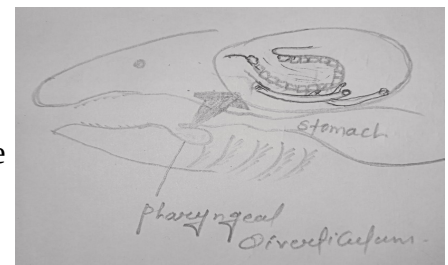
(3) Epithelium lining of buccal cavity :- The epithelium layer of the mouth or buccal cavity is very efficient for extracting oxygen from water or air, in some fishes. The transportation of oxygen from water or air to bloodstream of fish occurs through diffusion. But this system is not very efficient for enough oxygen for body mechanism.

(4) Alimentary canal epithelium lining :- In some fishes like loach and Loricariidae, there is modification of gut epithelial cell which perform respiratory as well as digestive function. Some part of gut like stomach and intestine become more prominent for this accessory function by reducing the thickness of gut tract and increasing the many thin blood capillaries into them. When fish take air from outer world especially Atmosphere, fish create internal gut pressure and therefore exchange of oxygen takes place because the gut epithelial cell lines entire length. These epithelial cell are very efficient for gas exchange. Finally the unused gases voided from anus. Remember the mechanism that exchange is due to diffusion of oxygen across the plasma membrane of epithelial cell.

(5) Labyrinthine organ :- Labyrinthine or labyrinth organ so called suprabranchial sac is outgrowth of suprabranchial arch (Gill arch). The organ is modified from the epithelial layer of upper gill arch especially first and second gill. The most important fish where this labyrinthine organ is present are anabantiformes or Gourami and also in fighting fishes. The labyrinthine organ as I mentioned is outgrowth of epithelial layer of suprabranchial arch so there are also an inhalant passage for entering the air into it. Because the organ is lined by epithelial cell so it's able to extract oxygen easily. This modified gill arch also has folds which increase it's surface area. The labyrinth organ should be moist when it perform it's function. The labyrinth organ also classified under the Branchial diverticulum.



(6) Pharyngeal diverticulum :- This type of accessory respiratory organ found in channa or snake head fish. In this organ has pair of outgrowth of pharynx and form sac like structure called pharynx sac or pharyngeal diverticulum. Because of presence of pharyngeal diverticulum the first two or three gill filamentous get reduced in structure. It is somewhat act like alveoli which have many blood vessels and perform gas exchange easily when moist epithelial cell layer inside the sac. This outgrowth of pharynx has capability for exchange of gases because of presence of efficient epithelial cell and many blood vessels. The gases can store into this sac only when fish take air from atmosphere.



Reproductive system of Fish

Reproduction is the process of passing the gene to the next generation. It's a production of new offspring or individual of same species. It is a very essential process of life through which new organism forms and continue to the species. Reproduction is a way thereby fishes and all the other organism creates their own new and much surviving individuals for their current environment. Reproduction is classified into two type:- (1) Asexual reproduction (2) Sexual reproduction. Asexually produced organism are genetically identical to their parents. Nearly all fishes are sexually reproduce but recent discoveries found that one of the amazon molly Species reproduce through asexually because it produce exact clone of their mother by parthenogenesis. Fishes reproduce widely via hermaphroditism and parthenogenesis. Parthenogenesis is a form of Asexual reproduction but more accurate **“Incomplete Sexual reproduction”** because in this reproduction involves gamete formation. Parthenogenesis is process of development of new organism without

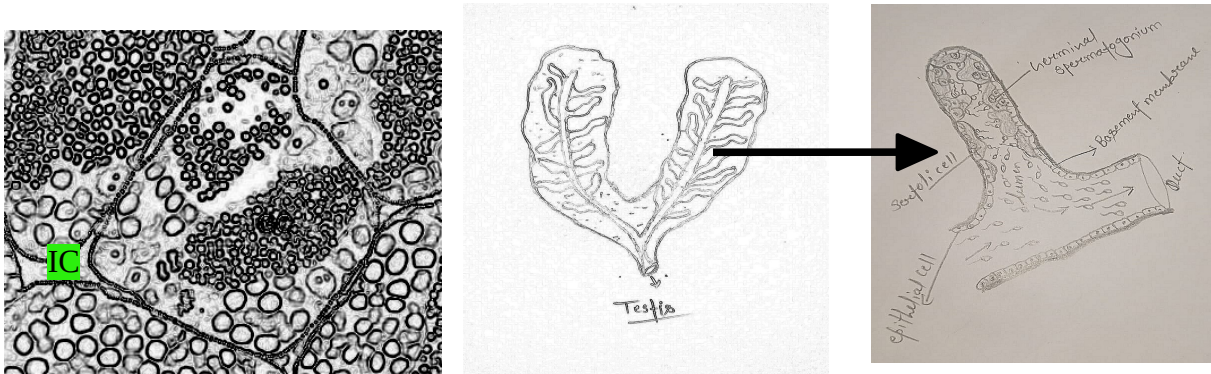
fertilization of egg. Hermaphroditism is generally considering a type of sexual reproduction but sometime it also refers as asexual reproduction. The hermaphrodite are those organism which have both male and female reproductive organs and their function. There are mainly three type (1) Synchronous or simultaneous hermaphrodites (2) Sequential hermaphrodite (3) Bi-directional hermaphrodite.

(1) In synchronous or simultaneous hermaphrodite fish occurs both Male and Female reproductive organ in same fish and mature at same time. Both sex organ male and female produce sperm and egg respectively at same time in same fish but self-fertilization occurs rarely. These produced egg and sperm mostly fertilizes other gametes of the same species or also with their own gametes. (2) In sequential hermaphrodite fish also posses both male and female reproductive organ in same fish but only one reproductive system active at a time. If male mature first and then change into female, called protandry sequential hermaphrodite but If female mature first and changed into male, it called protogyny sequential hermaphrodite. (3) Bi-directional hermaphroditism is quite rare and found in very less fishes, in this reproduction the fish can change It's sex more than one time that mean first fish if change from male to female than it can also again back change from female to male. Example of Bi-directional is coral goby.

Parthenogenesis is quite different than other type of reproduction because in this process new individual developed by without fertilization of egg. Parthenogenesis is two type natural and artificial parthenogenesis . In natural parthenogenesis fish egg developed into new individual without fertilization of egg through naturally. It is also two type (1) Complete natural parthenogenesis; in this process individual develop through without fertilization of egg which shows true parthenogenesis because occurs complete self-reproduction. (2) Incomplete natural parthenogenesis ; In which both parthenogenic and sexual phase occurs. If egg fertilizes then it developed into female but if egg not fertilizes then developed in male.

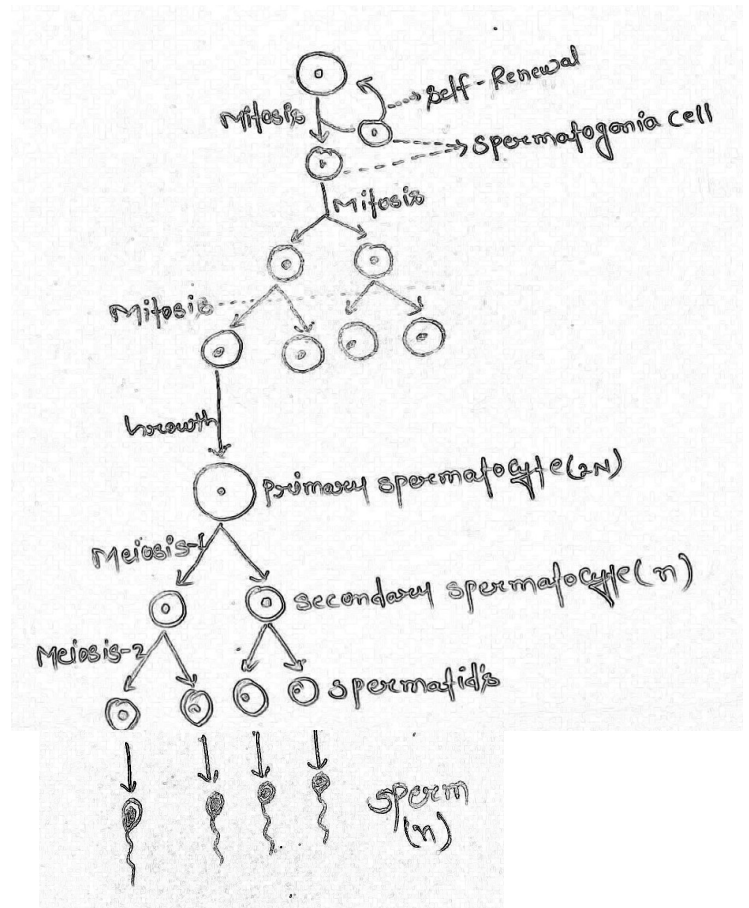
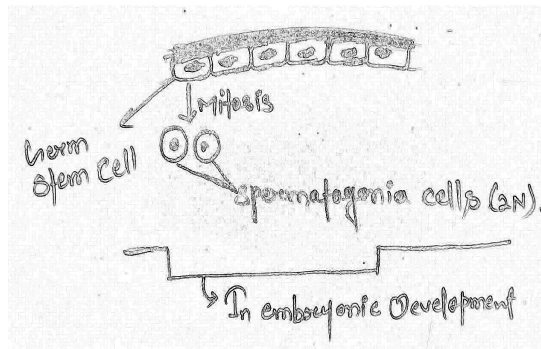
(1) Fish Male Reproductive system :- Male reproductive system consist pair of elongated testes which lies near to kidney. In ancient fishes the number of testis was different because they had only one in dorsal body cavity. The size and colour of testis can vary accordingly on species and also vary to maturity stages. In spawning stage and spermatogenesis stage the size and wight of testes become bigger and heavy compare to rest of stages. The pair testes located in dorsal or near to kidney which attached with body wall by connective tissue called mesorchium. The two lobe which forms pair of testes are Lobe A and Lobe B, each lobe has anterior and posterior part. Both lobe of testes join to each other by duct arises from each lobe of testes which ultimately open into genital pore and finally expelled out through genital pore. As I mentioned, Each testes lobe have anterior and posterior part so mostly sperm production involved in anterior part because of high number of germinal epithelial cell while posterior used to store them and passage the sperms. There is two type of cell (1) Somatic cell (2) Germinal cell. Only germinal cell involve in formation of gametes but somatic cell develops whole body. Each testes are rich with by germinal epithelium layer. The elongated testes may have two type of seminiferous (1) seminiferous lobule (2) seminiferous tubule.

Most fishes have seminiferous lobule like Salmoniformes and others possess tubular. The seminiferous lobule is lobular and connected to common duct for passing those formed sperm toward genital pore for example see the below diagram. The interstitial cell (IC) or gaps region among these seminiferous lobules are found to have Leydig cell which produce hormones needed to homeostasis the function of secondary sexual characteristics. The seminiferous lobules are made by germinal epithelium and somatic Sertoli cells which is separated from interstitial region by basement membrane.

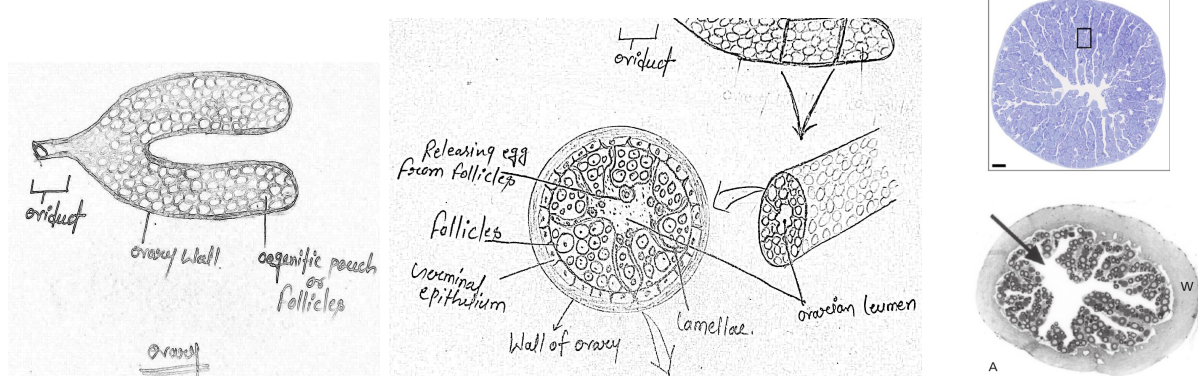


The seminiferous lobule, inside there are germinal epithelium cells which produce spermatogonium cell. Nearly all germinal stem cells produce spermatogonia cells in the embryonic development of fishes. These spermatogonia are found in inactive form at very side of previous stem cell. Spermatogonia being inactive until fish matures and then divide by mitotically into two spermatogonium daughter cell where one behaves to function as of previous spermatogonium cell and second daughter spermatogonium further involves in spermatogenesis. The purpose for mitosis division on spermatogonium cell or germinal cell is for increase the number of sperm that will increase the chance of fertilization. These spermatogonium cell are diploid ($2n = 50$ in catla) in nature. After the formation of spermatogonium in adequate number, one of the spermatogonium mature and grow into diploid Primary spermatocyte ($2n$). During this growth period of spermatogonium cell, it enlarge and duplicate its DNA to form sister chromatid on each homologous chromosome. This phase of duplication by mitosis is initial phase. Each primary spermatocyte makes Meiosis-1 and produce two secondary spermatocyte with half number of chromosome (n) because meiosis-1 is reductional division which divides each homologous chromosome. Meiosis-1 is long phase and it has prophase-1 where crossing over takes place. Each secondary spermatocyte makes meiosis-2 to produce two spermatid that means total four sperm is produced from one mature primary spermatocyte. In meiosis-2 the division occurs on sister chromatide so the number of chromosome are same as in secondary spermatocyte which is haploid. Next, spermatid mature and form spermatozoa or sperm by process called spermiogenesis. The spermatogenesis time varies according to species and ecology because tropical fishes have short period than cold region fishes. In spermiogenesis occurs the reduction of cytoplasm and most of cell organelle like Golgi apparatus of spermatid cell. Centriole arranged themselves to form microtubular flagellum of sperm.

After formation of sperm, sperm may stay for while or release down into final duct for leaving out of the body and fertilize the egg. Note that most teleost of higher bony fishes have no acrosome in fish sperm which probably shows the presence of micropyle on egg cell but in chondrichthyes and most other ancient fishes have acrosome. The micropyle allow the entrance of sperm and therefore fish sperm can contribute their genetic role in egg fertilization and formation of new individual fish.

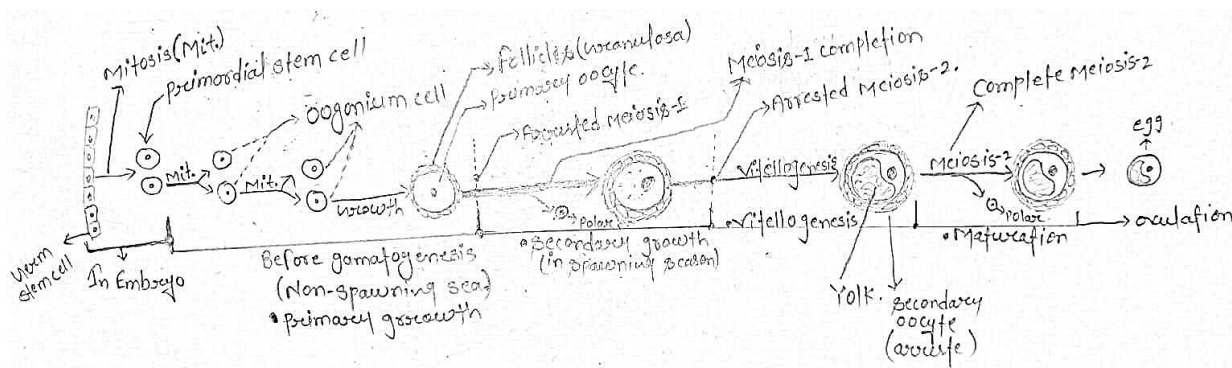


(2) Female Fish reproductive system :- Female reproductive system consist pair of elongated ovaries lies on dorsal part part of body near to kidney. These pair of ovaries attached with body wall of fish by layer of connective tissue called mesovarium layer. Like testes in male fish, ovary size, shape and colour changed with maturity stage and type of species of fishes. At the reproductive stages, the ovary becomes dark and weighed but after spawning, ovary again become smaller and lighter in colour. Both lobe of ovaries which forms pair are attached to each other or may be separated from others. Mostly Female ovaries actively form egg in anterior part of ovary but at posterior part has storing and passage function. The Pair ovaries attached to each other by duct called common ovarian duct at posterior region. Each ovaries composed of ovarian wall where the inner most layer is called germinal epithelial layer. The inside of ovary contain many oogenetic follicles which has consist egg cell. A oogenetic pouch/follicle have a oocyte or egg cell. The oogenetic follicle covers the egg cell by epithelial follicle cells called Granulosa cells and theca cells. At developing young egg cell have no follicles or granulosa cell around it but as process proceed the deposition of follicles cell takes place. The inner wall of ovary that has consist germinal epithelial cell which gives rise oogonium cells. The ovarian lumen provides a passage for traveling of the formed egg to oviduct (As diagram). There is basement lamellae which separate the developing oocyte from stroma or ovarian lumen. There are many lamellae which separate from each other and consist many egg cell with follicles. The blood and nutrient derived from blood vessels by mesovarium pathway of blood vessels. The ovarian lumen is rich with stromal fluid which derived from lining of epithelial cells on lamellae.



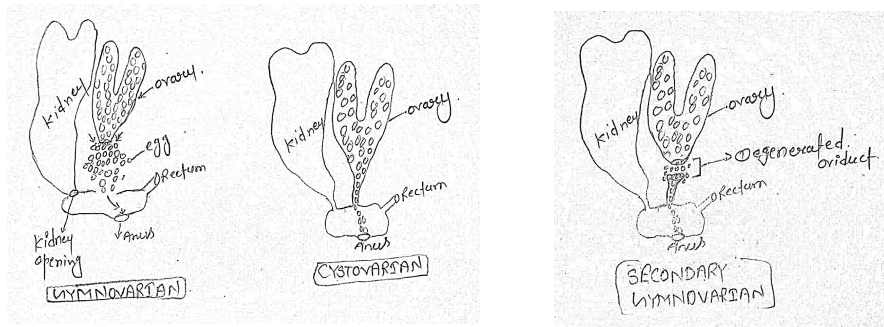
The germinal epithelial stem cell lines the inner most layer of ovary. These stem cell are so called primordial stem cells, are mitotically gives two daughter oogonium cell. These oogonia cell mitotically divides in many oogonia because to maintain proper number of egg cells. Unlike human female, The mitosis division of the primordial germ cell occurs throughout the life and therefore the number of egg maintain at each fecundity. “The process of oogenesis occurs in four steps; Primary growth, Secondary growth, Vitellogenesis and maturation”. **In primary growth;** At each non-spawning season or before the spawning of fish, the primordial germ cells divide into many oogonia by multiple mitosis division one after one. The conversion of these oogonium to primary oocyte results in the formation of sister chromatid on homologous chromosome and also the cell enlarges. As primary oocyte forms, the granulosa cell arranged together on egg cell to form follicles. These deposition of follicle cell on oocyte cause to associate with lamellae membrane. The primary oocyte which have now follicle cell (granulosa) with diploid number of chromosome start meiosis-1 but arrested in Diplotene sub-stage of prophase-1 of meiosis-1 at the time of every non-spawning

season or before the spawning time. **Secondary growth;** The arrested primary oocyte begin to complete meiosis-1 during the 'spawning season'. The completion of meiosis-1 to form one secondary oocyte (n) and one polar body. The formation of polar body take place to dispose the extra enough chromosome by degenerating them. The secondary oocyte which just formed, start meiosis-2 but arrested in metaphase-2. **The vitellogenesis;** Vitellogenesis Proceed to deposit the yolk in the developing oocyte. The major yolk protein is vitellogenin which formed in liver cell with help of ribosome, ER and Golgi apparatus. Once the vitellogenin formed it transported to oocyte by bloodstream. The developing oocyte take vitellogenin along with many vitamins and electrolytes by receptor mediated endocytosis where the clathrin coated vesicle fused to endosome and dissociate the nutrient and send to developing yolk in oocyte. This process of accretion of vitellogenin and many other nutrient called vitellogenesis. **Maturation;** After the vitellogenesis the maturation process proceed to complete the arrested meiosis-2 in metaphase-2. The arrested secondary oocyte (Haploid) complete the meiosis-2 and form haploid mature egg cell and one polar body. Now egg cell ready to ovulate therefore the lamellae membrane punctured at point to release the egg into the lumen. One of the important follicle cell, Theca cell, arranged together on preexisting granulosa on egg cell at the time of 'Formation of secondary oocyte'. Both follicle cell (granulosa and Theca) being a steroidogenic nature which forms Estrogen (E2; Estradiol) hormone by result of FSH action on these follicle cells. After ovulation the ova or egg released via these following type of ovaries;-



Fish ovaries are three type:-

- (1) Gymnovarian ovaries :- In Gymnovarian ovary the egg directly shed into the coelomic cavity of body because of no oviduct. The egg then allowed to enter in ostium of genital pore and finally expelled out. For example; Cyclostomata.
- (2) Secondary Gymnovarian ovaries :- In which the egg first shed into coelomic cavity of body but there is degenerated oviduct at point so egg then penetrate into opening of oviduct to release outside the body of fish. It is found in Salmonidae.
- (3) Cystovarian ovaries :- in this kind of ovaries , the oocyte directly release from ovaries to surrounding environment by small ovaries duct called oviduct. The oviduct connected to ovaries and genital pore so it make pathway for releasing of egg. For example most teleost.



The process of releasing of egg at particular time termed as spawning and the number of egg released per spawning is fecundity. The common ovarian duct or oviduct fused to genital sac and open in it. The property of egg will be discuss in next moment.

Lateral line system

The fish is highly sensitive organism, not only because of presence of eye but also for many Electrosensory and Mechanosensory organs including olfactory organs, chemoreceptors, inner ear system and one of the important Lateral line system. Our discussion is on lateral line system, The lateral line is mechanosensory organ which is sensitive to water disruption, pressure fluctuation and water movement. The lateral line system of fish is a type of sensory organ through which fish used to know even about very small frequencies of movement in the water body. This sensory system also used to determine the object in pathway of fish, speed of other unknown organism and shape of organism by detecting the pattern of water wave by lateral line system. The functional unit of lateral line is **Neuromast**. The lateral line system extending from end of tail region to head of the fish but also found on other location of fish body like snout, below the operaculum and trunk of the body. The lateral line system is also important for detecting surrounding fish movement and some type of vibration which created by predators. This lateral line is the sensory organ of fish which present on each side of the fish body.

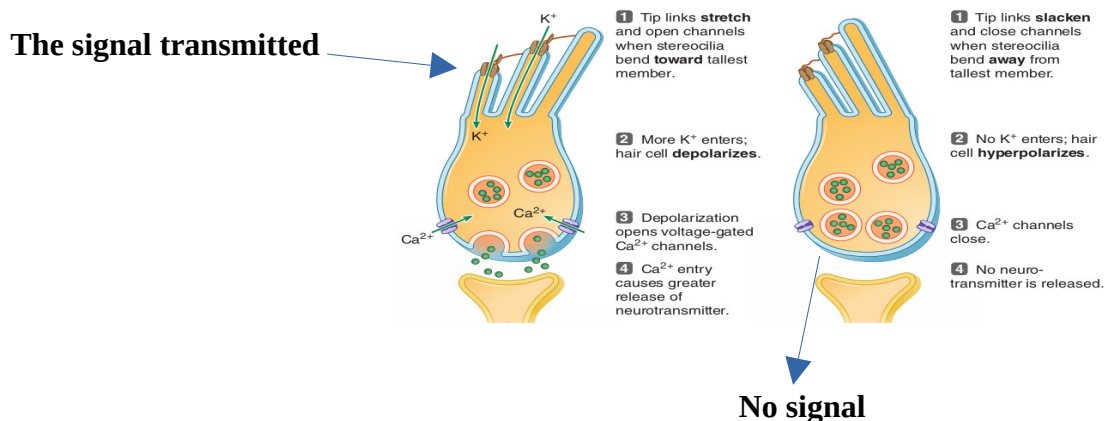
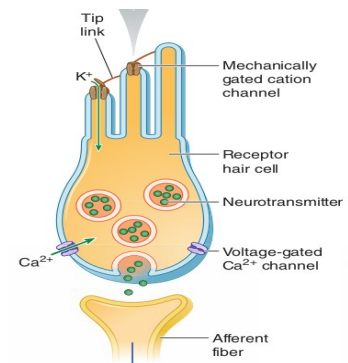
One of the important feature of lateral line is in the Schooling behavior of fish. This system provide the sense through which fish maintain the distance from each other while they all are swimming. The lateral line also protect the fish itself by bumping with aquarium glass, rocks and any obstacle. Nearly all fishes have this peculiar system but some fishes from oceanic sediment do not, the shape, size and position of lateral line may varies according to fish species. The main function of Lateral line is that fish used to detect any movement in water body, fluctuation in water pressure, obstacle around the fish and distance of disturbance creator (Organism who producing water wake). Because it's a mechanosensory organ so lateral line detect the mechanical changes. The lateral line present in series sequence from head to tail but at head the system branched into three part. One part moves upper to eye called **supraorbital** canal. Second move below to eye called **Infraorbital** canal and third reach in lower jaw which called as **mendibular** canal.

As you know the unit of lateral line system is Neuromast. The neuromast has consist many cell and neurons which contribute it's proper function. The cells are Hair cells and supporting cell and

neurons are afferent neurons and efferent neurons. The neuromast are present in epidermis layer of skin among the epithelial cells. The scaly fishes provides a small gap between scales region for it's development. The hair cells is originate from supporting cell that means the supporting cell replace the hair cell after each interval. The hair cell is a sensory cell which have many Cilia of smallest and Tallest on apical surface. These cilia on hair cell is must important structure where the smallest and tallest cilia always found in one side as like diagram below. The cilia of hair cell covered by gelatinous cap called Cupula which is very flexible and it can rotate 180 degree. The afferent neurons carries information from this organ to brain stem/cerebellum of brain. Efferent neurons controls the function of lateral line.

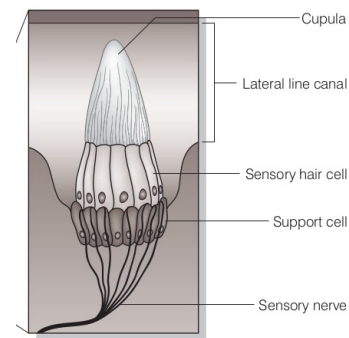
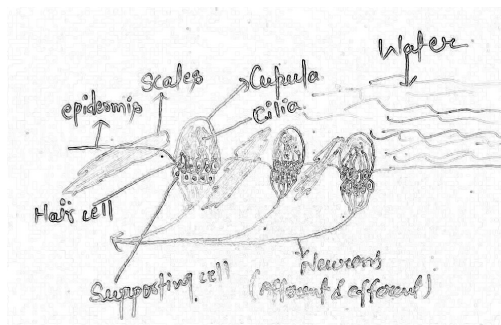
When water movement occurs, the Hair cell receives signal and send to the brain by afferent neurons because the movement of cilia caused by water movement. Cupula movement is because of water fluctuation and therefore the cilia rotates. The water movement allow the rotation of Cupula and ultimately bends these cilia of hair cell.

The mechanism of signal origination and transduction is quite complicated because there is many channels on the tip of cilia, when cilia of hair cell moves in direction of tallest edge then the channels get open and hair cell depolarize therefore the potential signal generated and carried out by afferent neurons. But the point should be noted is that when cilia moves in smallest direction then signal does not transmitted because of closed channel. So the conclusion is that the position of these neuromast and cilia found in such a orientation which allow the fish to receives signal from any direction. There are two type of Lateral line system in fishes;-



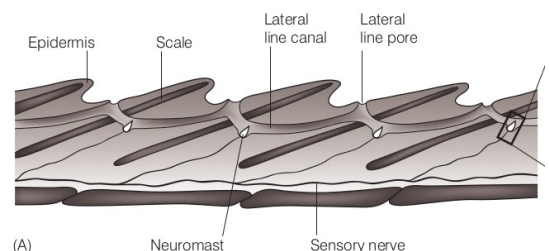
(1) Superficial Neuromast Lateral Line System :- It is also known as pit neuromast because In this type of lateral line system, the neuromast is present free standing on the surface of epidermis layer of skin. The superficial lateral line found abundantly on head region of fish and also occurs on body of fish. The superficial neuromast are very sensitive for small frequencies and it's cilia covered by gelatinous cap called Cupula. The superficial neuromast are direct contact with surrounding water where the fish swims and this is the reason that indeed a very small change in water is also detected by fishes.

The arrangement of these neuromast is extremely important because asymmetrical cilia signal formation requires the orientation of neuromast in all such direction by which hair cell can receive signal. Simply, each neuromast oriented in each direction.



This superficial neuromast is made by flexible cap which cover the hair cell growth as you see in the diagram. The base of flexible cap supported on hair cell, this hair cell has nucleus, mitochondria and different important organelles. From each hair cell originate efferent and afferent nerve which carry signal. Efferent nerve carries signal from hair cell while afferent sends signal to hair cell.

(2) Canal Neuromast Lateral Line System :- In this type of lateral line the neuromast is present in fluid-filled canal as you can see in the diagram. The canal neuromast extends from tail to head region of fish but at head the series sequence of canal neuromast branched into supraorbital, infraorbital and mandibular canal neuromast. It is distributed in series pattern because these neuromasts are found in canal which extended from tail to head. This canal lateral line system is embedded in the epidermis layer of skin and near to the scales. Canal lateral line system has many pores which are present at each interval where one or two neuromasts are located within this interval of canal pore. When water movement occurs, the neuromast catches the signal by receiving from those pores of canal. The water fluctuation of any obstacle detection is based on same principle as earlier mentioned that canal is already filled and when vibration originates thereafter the changes found in canal which cause to create signal in neuromast. This canal neuromast is sensitive for high frequencies.



For more obvious, this is the system of sense through which fish can predict what's going around it and therefore they can protect themselves from predators. For example, if you have ever seen the fish in an aquarium, they never bump with glass. Have you ever realized why? Because of this lateral line system. In fishes apart from detection of those valuable functions by lateral line, the neuromast system also provides a very specialized feature that wherever fish swim, they create their own water movement and fish knows very well of their own originated movement. When these wakes of water created by the fish, collide with glass first then fish get aware that their originated movement destroyed by something and therefore fish change its direction.

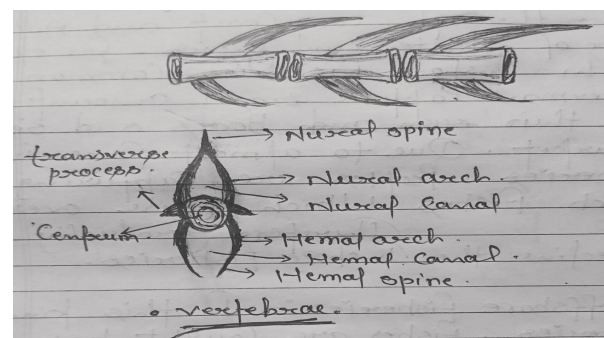
Basic knowledge of endoskeleton system of marine and freshwater fishes

The basic structure of fish is based on its Endoskeleton by which fish get its shape, size and form. The basis of fish body is achieved during embryonic development by different endoskeleton. The pattern of endoskeleton provide not only shape and size but also the ability to swim fast and swim against the current as most Salmoniformes and Scombriformes and others. As we know that two type of fish are (1) elasmobranchii and (2) bony fishes. Elasmobranchii have cartilaginous endoskeleton which is made by chondrocyte cell with other composites. In contrast to bony fishes, its endoskeleton made by bone which is osteocyte and other composition.

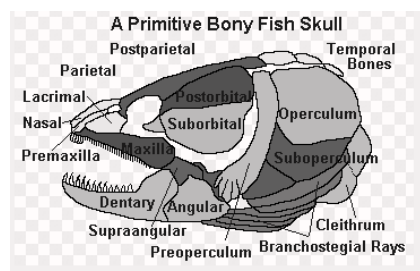
Fish have diverse range of endoskeleton which have adopted to reflect verity of function. The fish endoskeleton have different part which are following :-

(1) Vertebrae :- Fish vertebrae are similar to humans but small in size. The Vertebrae are present in the form of vertebral column which extended from tail region to head. The vertebrae in elasmobranchii made of cartilage but in bony fish it is formed from bones. The vertebrae are reorganize to form vertebral column in which spinal code persist. Vertebral column have very unique structure which provide the structural support of the fish. The vertebrae have unique structure as you can see in the diagram. In fishes the vertebrae are somewhat sharp and small. The fish vertebrae is also use t study the age of fish by determining the growth of centrum (A small central part).

Each vertebrae have three distinct part; Neural spine , Centrum and Hemal spine. Both Neural and Hemal supported by centrum. Ultimately, These spine supports the fins rays and ribs.



(2) Skull :- Fish skull is complex structure which is made-up of many combinations of bones or cartilage. Each component of skull of fish head provide a shape of fish head. There are following structure;-



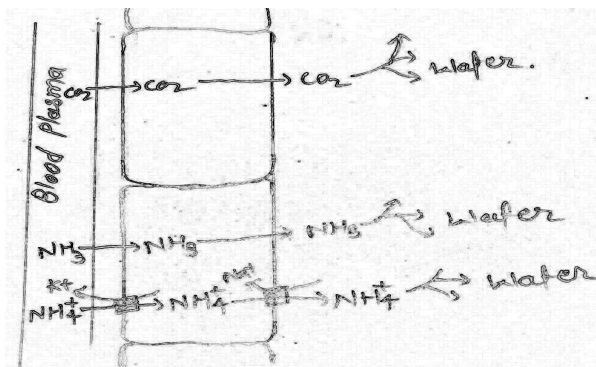
(3) Fin spine and girdle :- Fish have different type of fins like pectoral, Anal , Dorsal and Caudal fin. These all fins are supported by spines and girdle with vertebral column bone and skull. Caudal fin attached with the end of the vertebrae.

Excretion in fish

The nitrogenous waste Ammonia is major waste product of fish by metabolism of protein and other organic molecule. The formation of ammonia in fish is the result of homeostatic machinery. The excess level of ammonia is very deleterious for fishes because it may damage the CNS by over-activation of NMDA glutamate receptor through which high calcium influx lead to death of neurons and ultimately death of fish. The elevated level of ammonia also lead to damage the proper function of enzymes and the homeostasis of fish. The high ammonia can increases by exercise like swimming, stress, environmental release of ammonia and metabolism of protein in fishes. Obviously, Fish is not a underrated organism because they have so many preventive mechanism to avoid the elevated level of ammonia ; first, by formation of Glutamine amino acid in brain. Fish reduce these excess ammonia by formation of glutamine but it's a energy consuming process which done by many carps, catfishes and other teleost. Second, by formation of Urea through Ornithine urea cycle. Urea is less toxic and this mechanism done by Singhi fish (ultimately expelled out by kidney) and elasmobranchii. Elasmobranchii convert this ammonia into urea and retain it in the body for maintaining osmoregulation. Fish have well developed excretory system including gills, Kidney and skin. In fishes the other wastage are unusual entered electrolyte's and excess water for particular fish. There are three type of excretion occurs in organism (1) Ammonotelic excretion found in most fishes including bony fishes, amphibians etc (2) Ureotelic excretion found in mammal, cartilaginous fish (shark's) etc. (3) Uricotelic excretion found in birds. Carbon dioxide is also a excretory molecule.

Fish have following system to eliminate and excrete the wastage form the body:-

(1) Gills :- Gills are the major excretory organ for excretion of ammonia / ammonium ion and carbon dioxide. Fish gills have large surface area by which it help to elimination the ammonia and these wastage end-product. The elimination of ammonia and it's related end-product from body of fish by gills to it's surrounding medium (water) is occurs through the passive diffusion process and Antiporter for ammonium ions.. Ammonia have high electronegativity difference so it is polar and therefore it's readily soluble in water. These wastage readily entered into gill cell from blood plasma and then eliminated from the gill or fish body, as you can see in the diagram.



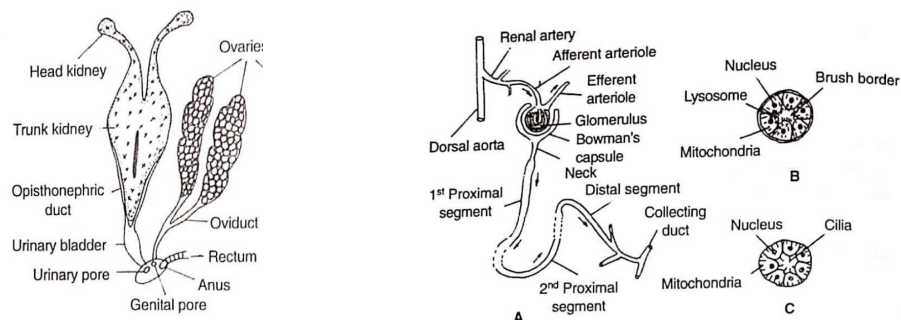
(2) **Skin :-** Fish skin is semi-permeable which allow the some ions and water to exchange. Fish use it's skin for elimination of excess water and ions like Na^+ , K^+ , Cl^- and other electrolytes. For example a marine fish live in highly saline water, in that condition, marine fishes lose it's own water molecule and gain much more ions from surrounding water through skin. Here in marine water fishes skin behaving like a excretory system for water but in freshwater the fish skin become excretory for ions. Although, it is exactly clear that skin is under the osmoregulatory system but the way through which it excrete is suggesting that the function of excretion.

(3) **Intestine :-** Intestine serves as the system through which the food molecule digest and unwanted molecule / undigested food eliminated from the tract. Because it is the elimination site of digesting molecule and those who undigested therefore the intestine is consider to be an excretory system.

(4) **Kidney :-** Kidney is one of the most prime organ for several function including Excretion, osmoregulation, activation of vitamin-D, removal of unwanted ions and so on. Fish kidney is dissimilar from mammalian kidney because kidney of fish are paired elongated structure lies at dorsal portion of the body cavity. The size and shape of kidney varies depending on the fish species because some species have both fused lobe of kidney while others have separated lobe. Each kidney have two part which is namely anterior and posterior part. Kidney produce a type of glycoprotein hormone called Erythropoietin/ Haematopoietic which activate the production of erythrocyte.

The kidney of fish has consist anterior and posterior part where the elimination and all the excretory function of kidney occurs in posterior region not in anterior because anterior is featured for production of Haematopoietic hormones and has lymphocyte. The fish kidney is type of mesonephric kidney. The unit of kidney are Nephrons which usually and abundantly found in posterior part of kidney. Each Nephron has connection with common collecting duct. Nephron receive blood from Afferent arteriol and after filtration in glomerulus, it then forms efferent arteriol. The glomerulus is very fine cluster of blood capillaries In bowman's capsule. Bowman capsule is collecting part for blood free plasma which filtered from glomerulus. Efferent arteries are the only arteries which carries oxygenated blood because of no oxygen taken at glomerulus therefore the efferent arteries then converted into peritubular capillaries on those Nephrons tubules. Finally, peritubular capillaries of efferent arteries meets the vein and leave the kidney. When blood comes to the glomerulus from afferent arteries, it extract the blood free plasma from blood content but not blood cells and any other plasma protein because of repulsive and small porous entrance on basement layer, capillaries and podocytes cell. The extraction of these wastage and electrolytes and water is largely depend on blood pressure and the cell of podocyte and capillaries. The filtered blood free plasma enters the bowman capsule and then into tubular part. When the blood free plasma reaches to tubular section including proximal tubule and distal tubule and final common collecting duct, these tubule Re-absorbs those ions and molecule which do not need to eliminate from body by mostly symporter and antiporter on tubular epithelial membrane at apical surface.

These Re-absorption largely depend on which type of fish they are and where they live. The secretion also occurs in this tubular region because there are some molecules still present in blood which have to be eliminated; therefore, these are secreted into the tubule from the blood capillaries. The urea in ureotelic and other wastes are finally reach to eliminating capillaries. For example, a freshwater fish they need to conserve some ions like Na^+ , Cl^- , K^+ , Ca^{++} etc. These ions re-absorbed in these duct and eliminate those products which have to be released and that's why freshwater fish urine is more diluted (more water than ions) and marine water fishes release more concentrated urine (more ions than water) but there is also adaptation and different function for this reason because those fish which produce large concentrated urine have small modified structure of glomerulus in such a way to eliminate more ions but less water. While freshwater fish have well developed and large structure of vascular glomerulus.



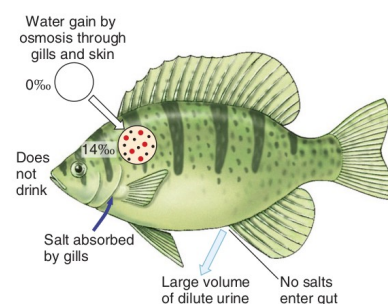
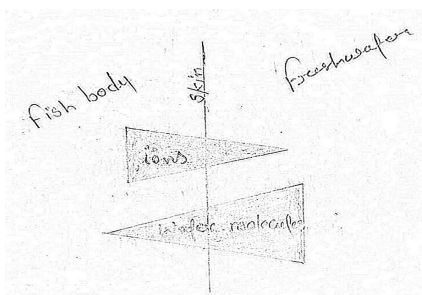
These Nephrons release those unwanted wastes into the collecting duct and finally remove from the body.

Osmotic and ionic regulation in freshwater and marine water fish

The term osmosis refers to the movement of water molecules (solvent) from a higher concentration gradient region to a lower concentrated area. The movement occurs across a semi-permeable membrane or simply spm. Diffusion is not only the movement of water molecules but for any substance from higher to lower concentrated area. Spm or semi-permeable membrane is a kind of membrane which allows only certain molecules to cross from it. Dilute urine means it has more solvent or water than solute or ions, while concentrated urine means it has more ions (solute) than water content.

Fish ionic regulation is a very interesting topic because in this system we mainly focus on how the ions and water molecules are regulated in the fish through skin, gills, and kidney. There are three types of fish based on salinity: Brackish water fish (0.5-35ppt), Freshwater fish (0.5ppt), and Marine water fish (35ppt). The term salinity describes the amount of solute ion dissolved in water (solvent). Now, in further discussion, we only consider two fish from its location: one is a marine fish and the other is a freshwater fish.

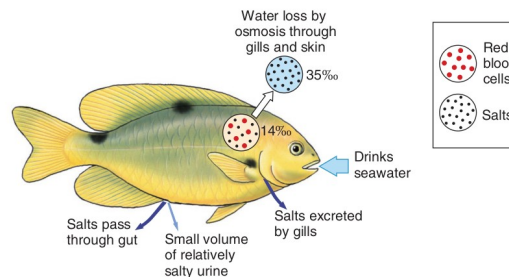
In case of Freshwater fish;- The Freshwater has 0.5 ppt salinity that means the surrounding water where the fish lives, has less ions (like; Na^+ , Cl^- , Ca^{++} , Mg^{++} etc.) but the presence level of water molecule is too much. As I mentioned that due to osmosis the water molecule move from higher concentration potential area to lower concentration area therefore in this condition the freshwater fish experiences some problem of losing it's **ions** and unwillingly taking of extra enough water from water medium where fish lives. Because the surrounding water have less ions and more water molecule therefore the ion which present in fish body (for it's normal metabolic activities) losses into surrounding water by osmosis and at the same time fish also gain extra water because of osmosis. These miss-balance of ions and solvent is maintained by ionic regulation of fish. In ionic regulation of freshwater fish, the loss of it's ions or solute into surrounding water from skin and body of fish is maintained and Re-uptaken from same water by active transport system at gills during gas exchanges. This active transport of ions and electrolytes from water to body of fish maintain and solve this problem. The buccal cavity epithelial cells are also more adapted to extract those electrolytes and ions. **Why freshwater fish don't drink water?** Only one reason is that freshwater fish unwillingly takes enough water from skins by osmosis and electrolytes (ions) at gills by active transport therefore freshwater fish do not need to drink the water. The chloride cell which present at basal region of secondary gill lamellae, are mitochondria rich cell. This chloride cell is actively transport ions from water into the fish body. Water not enter into the digestive tract but the fish takes enough water by osmosis henceforth now fish intend to eliminate those excess water from the body. Kidney plays very important role here, the freshwater fish glomerulus of Nephron is larger and capable for elimination of more water than electrolytes therefore the urine formed in these fishes are diluted. The electrolytes or ions are actively Re-absorbs in tubule of Nephrons so there is no chance to loss valuable ions from urine formation. The only way by which freshwater losses it's ions is the osmosis.



In case of Marine water fish;- The marine water has high salinity above 35ppt. Unlike freshwater fish, Marine water fish experience losing it's water molecule and entry of extra ions or solute through skin/body from surrounding water due to osmosis. This problem fixed by the process of ionic regulation. In ionic regulation of marine water fish, the losses water molecule Re-uptaken or Re-absorbed by buccal cavity and through digestive tract by drinking the water from mouth.

Therefore, marine fish drinks seawater through mouth. When fish takes water from mouth, the water moves down to further digestive tract where taken water absorbed but at the same time fish also takes-up extra enough ions from the skin. Because water is already contaminated with much more ions therefore when fish drinks water, fish unwillingly drinks those ions along with water.

As we described earlier that chloride is one of the most important cell involves in ionic regulation. Unlike freshwater fish chloride cell, the Chloride cell of marine fishes are adapted to actively excrete those excess ions but this is not consider to be a prime site for excretion of those enough ions. Because marine fish used to excrete enough ions by forming concentrated urine. Kidney of marine water fish capable to minimize the elimination water and maximize the elimination ions. The marine fish has also modified small glomerulus and Nephrons tubules which actively Re-absorb water and allow the exit of ions therefore marine water fish urine is concentrated.



Note that, Shark (or elasmobranchii) and some other fish are Ureotelic fish. These fishes produce urea by ornithine urea cycle as less toxic nitrogenous wastage but they do not excrete from body instead retain in the body and circulate in blood. The TMAO is a molecule in shark which reduces the damaging effect of urea. This retention of urea makes shark isotonic with seawater therefore shark freely enjoy their live without fear of dehydration. This feature for enhancing the blood urea concentration is due to modification of kidney and present type of cells which allow to conserve urea for increasing the level of blood urea concentration. **Well, This is an interesting question that do sharks drink water?** Because shark is Ureotelic therefore it's body is already matched with the seawater salinity. Sharks used to drink very less water as other marine fish do. Hence shark excrete very less concentrated urine. It is also not accurate to say that shark completely fearless of losing it's ions instead very less electrolytes might be lost.

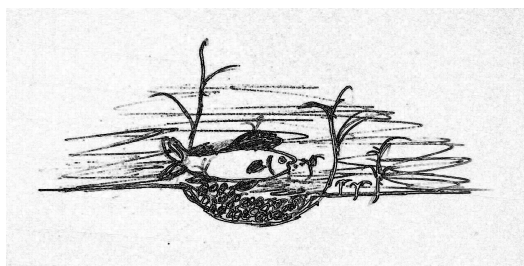
Reproductive behavior and parental care

Reproduction in fishes is very diversified where male fish and female fish posses testes and ovary respectively which perform very important role in creating new individual. The reproductive behavior is an action and behavior which express by fishes for reproduction. The term reproductive behavior refers the action, attraction, chasing, courtship and mating of fish. In reproductive behavior the fish either male or female express it's behavior to initiate the reproduction. There are so many ways through which fishes act for this behavior. The most recognizable reproductive behavior by fishes is courtship; in courtship of fish, mostly male fish displays their behavior like coloration, swimming around female fish and any other attractive behavior by male fish while female select those male on the basis of male behavior therefore male are displays the behavior and female are selective of behavior. Another important reproductive behavior is dominance among

same sex of fish like male-male fish or female-female fish fights each other and creates their dominance. These are the major reproductive behavior by fishes which occurs in response of their maturity. When male or female fish attain maturity by exposure of gonadotropic hormones as a result fish start behaving for reproduction. The migration is also considered to be an important reproductive behavior among fishes especially Salmonidae species. The term sexual behavior and reproductive behavior are closely related terms but reproductive behavior refers to a range of behavior under the reproduction like spawning, migration, courtship and dominance etc, but sexual behavior refers to the behavior expressed by fish especially gametogenesis and mating.

As all humans are very caring for their offspring, some fish get this change to care and protect their offspring. Parental care is a special type of care (behavior) and association between parents and their young one (offspring) to increase the chance of survival. It is usually not found in all fishes but some fishes do this unique behavior. The parental care of fish can be described as the close association of parent's and its young one or individual to protect them and make a suitable environment for proper growth of fish. In parental care behavior, parent's of their progeny care themselves for enhancing the chance of surviving because there are so many predators who are waiting to eat them; therefore this feature may help to protect and increase the chance of survival. During parental care either male or female or both guard and protect the egg until the new fish complete the metamorphosis or egg stages. Only 25 percent of fish shows parental care including anabantiformes fishes, perch-fishes, cichliformes fishes etc. In most parental care, male or female or both protect their offspring up to adolescence of new fish by creating a protective shield for them and also parents guard every time. There are following types of parental care shown in fishes :-

(1) Nest building :- In some fishes like perch and cichliformes show nest building behavior. In this parental care either male or female or both prepare a nest on sediment of water column or with help of plant debris. Mostly male form the nest and female lay/ hatch egg in it. The parental care prolongation can vary among fishes because some fishes used to protect and behave parental care until newly fish get adolescence stage while others are only protect their offspring for early development of newly spawned fish. There are many fishes which create the nest and they leave after spawning. In very particular fish species protect nest until death of parent fish. In this parental care by fish, select the suitable place and make nest by snout and body rubbing the ground. Different types of nest building can be observed in fishes on the basis of environment and species like:- (1) Circular nest (2) Floating nest (3) Hole nest (4) bubble nest.



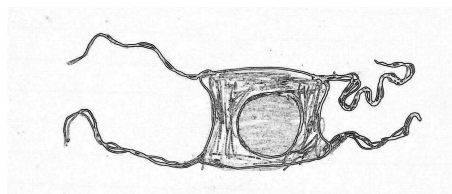
(2) Mouth incubation of egg :- In certain fishes like cichlides, mouth provided as shelter for newly hatched young one. These fishes have special type of modification in mouth which help in keeping the larvae in mouth or buccal cavity until larvae get mature and able to protect themselves. During this incubation period of the newly fishes, the parent fish do not eat food. In recent research, it appear that parent fish can release their offspring in water for a while and therefore parent fish take food and rapidly incubate again their egg or offspring in mouth.

(3) Attachment to the body :- Some fish have special type of parental care, in this association the newly hatched fish have special modification which attache to it's parent around the body. Two type of attachment shown in fishes first ;- Each fish larvae separately attached to parent body at different location. Second ;- All larvae get grouped into membrane and then attached to body. For example, Gar fish, butter fish and some cat fishes.

(4) Brood pouch :- It is seen in Syngnathiformes fish especially sea horse. In male sea horse have brood pouch at abdomen which is not found in female sea horse but it not mean that male sea horse produce egg instead male have only job to retain that spawned fertilized egg. Female only lay her egg and the process of brood pouching is under the male so male fish retain all newly young one until they mature over a time.

(5) Cephalic hook on head :- In Nursery fish have this type of parental care. It is not commonly found in fishes but in this type of care, a parent fish have hook like stature on head which provide as shelter for their egg. All the egg make group under membranous cover and get attached to their hook like shelter on head.

(6) Mermaid purse:- This is characteristics of sharks and skates. It's a kind of adaptation of egg because egg retain in slightly thick membranous covering around the egg. This membranous covering called as mermaid purse which have four arms like filamentous thread which probably help in attachment to something. Inside the mermaid purse contain mucous, nutrients and egg for shark baby growth. It's a black and brown coloured purse that float and remain stationary in water column.



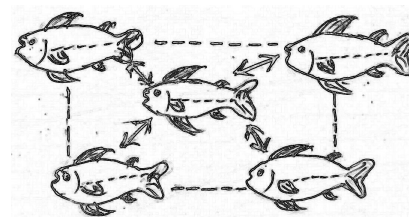
(7) Oviparous and ovoviviparous :- It's a kind of process by which fish lay egg. If fish lay egg not directly give birth of new young one then it called as oviparous. In ovoviviparous fish, fish lay egg but retain inside the body until fish larvae get mature and then hatched to produce new offspring.

Social behavior– Aggregation and Shoaling & schooling

Social behavior is special kind of interaction or association with same fish species. The term social behavior can be understood by imagining the conditions within a “Society”. In social behavior the fish from the same species live together and conduct their life. In the social behavior of fish, fish can reproduce, spawn, swim and protect each other from any attack by predators. For example, 100 fish living separately in different locations then the chance of survival becomes low compared to those who live in social or group. Social behavior can be innate or acquired depending on fish type and species. Social behavior includes reproductive behavior, close association between fishes, swimming together and fighting with predators for each and every life. Social behavior of fish is a grouping behavior which has different reasons.

Social behavior is the way by which fish increase their survival chances because of many reasons like temperature maintenance, reproductive strategies and many more. Social behavior is classified by Aggregation and Shoaling. Aggregation refers to the gathering or grouping of any kind of species of fish, either same species or different species together for different reasons including all the life-sustainable things, for example; Temperature maintenance, reproduction, swimming etc. As the term refers, aggregation means grouping or coming together of something and someone. For example, in 100 fish, there are species of Anabantiformes, Cichliformes, Salmoniformes etc. that aggregate together to form a kind of social or society and this entire association is termed as aggregation of fish.

Shoaling and Schooling are two closely related terms but functionally they are different. Aggregation is just the simple interaction and association of any fishes but the two terms shoaling and schooling are different because in both of them occurs specialized interaction, association and closeness of same species for particular purposes like reproduction, feeding, swimming and for many more including protection of new offspring in group.



The term shoaling mainly refers to explain the normal non-synchronized and non-organized grouping or interaction of same species of fish. In shoaling the fish still belongs to same species and have many intentions for maintaining the shoaling but they are not exactly in disciplines and synchronous. So, shoaling is loose interaction among same species of fish in social behavior. In contrary to schooling, schooling is very much synchronized and organized interaction among same fish species for many purposes and earlier mentioned. In schooling the species of fishes are always in discipline and when one or two fishes from the top of swimmer move in any direction, all fishes

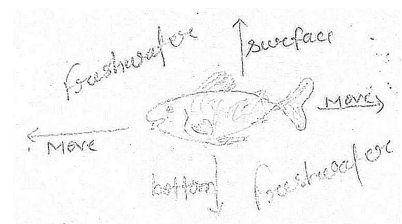
in schooling move in those particular direction. Fish move with maintaining particular distance among them therefore each and every fish in schooling swim easily. So, overall the schooling of fish is extremely synchronized and organized grouping of fish while swimming. This schooling help to provides fish protection and barrier against predator.

Every fish afraid of any predator which is top from their tropic level. For protection, they participate to create/aggregate group which not only protect from predator but also help to get food and reproduce easily. Each fish maintain schooling while swimming through their lateral line system. Because lateral line is very efficient to detect any obstacle and other swimmer around them easily therefore fish synchronized schooling.

Fish migration

The Migration is the movement of group of organism or population from one habit to another place of habits. Fish migration is also the movement of fish school (socially fishes) between habits are termed as fish migration. As name suggest that fish moves from one habit to another habits for certain purposes including breeding, feeding, competition among fishes and others. Fish is aquatic organism which breath with gills and move with paired and unpaired fin instead of limbs therefore fish migration apparently occurs in water world. The fish migration or movement depends on several factor because migratory fishes use different cues to find their ways to reach the destiny. The major factor used by fishes for migration is sun-light, temperature, Salinity and body internal clock. It might be difficult to understand all the factor in migration and how all these factor work together to provide exact partway for reaching to their fish habit destiny. Because fish use their internal hormonal control system and all the sensory system like mechanosensory system,olfactory system and chemo-sensory system to complete the migration. Only limited fishes are migratory fish, most of the species of salmon spp., Trout spp., Anguilla spp., sea lamprey , hilsa spp. Herring spp. etc. are most recognizable fish of migration. These are following general classification of fish migration:-

(1) Potamodromous :- Potamodromous type of fish migration entirely occurs in freshwater. In this migration, fish migrate from one specific habit to another habit but within freshwater. Fish migrate or move from either surface to bottom (or vice versa) and between different habits in freshwater. These fishes migrate for several reasons like spawning, feeding, competitions between fishes, protection against predator and also for finding new place. For Examples; Trout, carps and some other freshwater fishes. These fishes migrate short distance and within same water therefore potamodromous do not experience any osmoregulation imbalance.

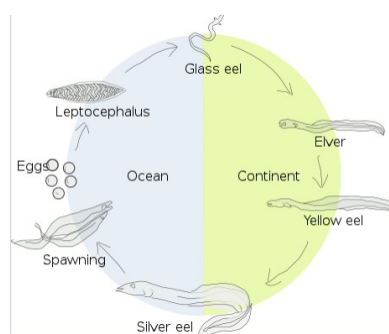


(2) Oceanodromous :- In Oceanodromous, the fish used to migrate from one habit to another habit in the same ocean water. The ocean is really an open world where verities of organism live and swims therefore in the Oceanodromous fishes migrate far distance and potamodromous fish do. The major similarities between potamodromous fish and Oceanodromous fish is that Oceanodromous occurs in same ocean water and as a result the salinity doesn't much therefore fish migrate without fear of osmoregulation miss-balance. These movement also fluctuate for reason of spawning, food and also for finding new mates. Oceanodromous fishes include tuna fish and hilsa fish and also herring. One of the most dreaded shark called The Great White Shark are a Oceanodromous. They are fast swimmer so they migrate much more distance in ocean.

(3) Diadromous :- Diadromous fish are truly migratory fishes which actually occurs between different water salinity and different water habitat. The major reason for migration is breeding or spawning but there are also another factor for which it migrate like seasonal balance, fish feeding behavior etc. Diadromous fishes covers very far distance because as it occurs in two different water habitat therefore fishes who are diadromous have well developed system for osmoregulation. These fishes divided into two categories which are following :-

(a) Anadromous :- This is type of diadromous migration where the fishes migrate from ocean to freshwater. In simple way, Anadromous fish spend their growth phase (or lives in marine) but migrate to freshwater for spawning or breeding. During migration it covers very long distance therefore fish spend their most of energy in swimming and also it is interesting to note that these fishes usually do not feed in entire migration. Because it is occurs between ocean water to freshwater therefore migratory fishes have to control their osmoregulation. These fishes move across through brackish water and then enter into freshwater, during all these location they tolerate different salinity of water. These fishes are Salmon, Trouts and Sturgeon etc. The major factor by which fish migrate is sun-light and salinity changes and also the very important factor that is fish body internal clock. These factors provide the well coordinated swimming of fish in particular direction for their destiny.

(b) Catadromous :- It is also a kind of diadromous where fish lives and spend their life phases in freshwater but migrate to marine water for breeding, spawning and also for finding new pace to live. These fishes live in freshwater but move to marine water as a result they experience much more osmoregulation. Like Anadromous, diadromous fishes also use all the cues for migration from one water habit to another water habit. The most important catadromous fish is eel or *anguilla* spp. And also some bagridae spp. The catadromous fish also migrate more far distance as like Anadromous fish.



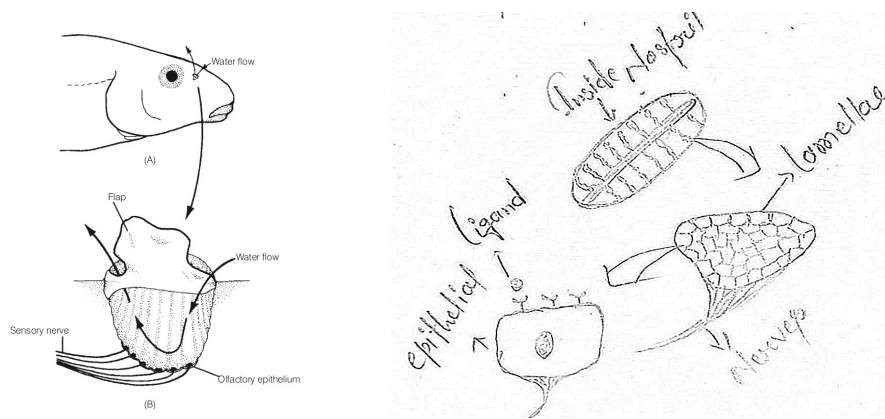
Purpose of fish migration:-

- (1) Spawning ; - Most of the fish like salmon, trouts and eel migrate for spawning purpose.
- (2) Food ; - Some fishes migrate for food and also for finding feeding area in case of absence of food where they had to live.
- (3) Temperature ; - Fish migrate from one location to others habit for many reason and one of them is seasonal temperature balance. Some fish lives in cold temperature while other are in warm water but when temperature decline or increases as season changes then fish migrate from their previous habit in search of new suitable location.

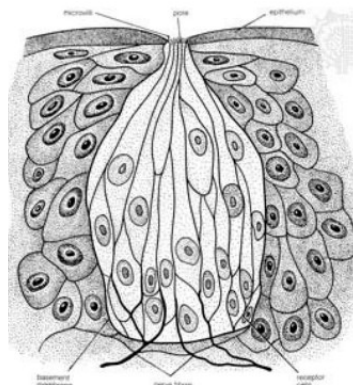
Chemoreception

Chemoreception is physical response to chemical stimulus by sense organs. Water environment is highly dissolved environment by solutes, gases and chemicals therefore fish have sensory organ through which fish used to detect the chemicals stimulus. Fish adapted to detect any chemical presence and change in water quality by using certain sense organs system. Chemoreception not only help in detecting the chemical stimulus but also provide signs of predatory activity, food, mating or reproduction. The Chemoreception divided into two major part; Olfaction (Smell) and Gustation (Taste). Both sense organ help in detecting several stimuli or signals. As name suggest “Chemical perception” is the detection of chemical by sense organs system in fishes.

Olfaction or smell sense organ are located in the nostrils which present at head of the snout. The olfactory organ is connected with central nervous system of fish by olfactory tracts (in CNS) and nerves (in PNS). The olfaction perception occurs in the anterior of telencephalon of forebrain. The cerebral cortex of this anterior part of telencephalon is specialized for detection of any chemical stimulus or olfaction. The smell sense of olfactory organ present in pairs, inside the nostril at snout . Fish snout have pair of nostril on left and right position in which smell sense organ are embedded. Each nostril is tubular or cage like structure which have two opening where one opening used for the water entrance and other opening is act like exit of water. Inside the nostril have many olfactory lamellae which is made of olfactory epithelial cell layer. Several epithelial cell have receptor for verity of chemical stimulus. When water is contaminated with many chemical stimuli and then enter into the nostril therefore olfactory lamellae which found in nostril is contact with those chemical contaminated water. There are thousand of chemical receptor on olfactory epithelial cell (olfactory lamellae made of these epithelial cell). The receptor which covers the olfactory epithelial surface are type of G-protein coupled receptor. Once the chemical stimuli binds to GPCR, as a result the cell (sense epithelial cell) stimulate the internal signaling pathways and allow the ions channel to open and depolarization the same sense epithelial cell. When cell depolarize as a result nerves receives signal which finally reach to olfactory region of brain for further processing. As you might expect that how different stimuli recognized? Because there are thousand of individual receptor which recognize each and every signal stimuli. It is just like human have odorant receptor in nasal passage.



Gustation or taste sense organ is second important type of chemoreceptor organ which present primarily in the mouth but also present on fins, lips, barbels and some other body surface especially in epidermis layer. The major function of this taste sense organ is that fish use this gustatory organ to detect the presence of food, chemicals and concentration of toxic molecule in water. The unit of gustatory system is taste bud which is made of many gustatory sense cell and epithelial cell. Each sense cell connected to neurons which receives information towards the Central nervous system for further information process. These cell are very efficient to binds varieties of chemical and food stuff. Like olfactory organ system, the gustatory system have GPCR for binding the stimuli and detecting the signals. Because the gustatory organ system is direct contact with surrounding water therefore these cell replace after every certain time of period by modification of epithelial cell into this sense cells. There are also many mucous secreting cell which help in binding of chemicals and stimuli of signal.

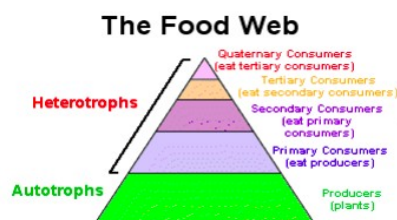


Last but not least, when the fish observed the high toxic chemical like ammonia in the water by using these olfactory and gustatory organ system therefore the fish start doing two interesting thing is that fish rapidly swim away from the high ammonia concentration area or start forming glutamine in the brain (or also start ornithine urea cycle) to reduce the excess ammonia which is moving into the fish body by simple diffusion. The factor for increasing the ammonia could be industrialization which producing excess ammonia and leaving into the water where the fish life occurs.

Biology of fish-2

Natural Food and Feeding Habits in Freshwater and Marine Water Fishes

Food is the basic & primary source of energy. Every living organism on planet earth requires food. The energy which extracted from the food is needed to sustain the survival of individual. Food is not only the substance through which organism can extract energy but also provide the essential molecules and ion which required for proper function of body and generation of new life (gametes). Obviously, food is the source of different group of essential and non-essential organic or inorganic molecules and ions like amino acid, lipid, proteins, carbohydrates etc. Fishes are the vertebrate creature which spend it's life under the water (Except some lung fishes) and move through their paired and unpaired fins. Plant is the first basic unit of food producer because they are autotrophs and produce their food from water and carbon dioxide with help of sunlight in the chloroplast. Therefore, plants are called as primary food producer. Animals they can't prepare their food themselves therefore they termed as consumer/ Heterotrophs. The food Consumer or heterotrophs may be primary consumer, secondary consumer, Tertiary consumer and Quaternary consumer on the basis of their food trophic level.



Fishes feed wide range of food material either from plant source or animal source. On the basis of their genetics and habits, they are primary consumer, secondary consumer and tertiary consumer. Fish food or simply Food is divided into following groups :-

(1) Natural food:- The food's which naturally found in water body are called natural food. These food are small in size and present within the same water body where the fish lives. Natural foods are present naturally in the water, are very diverse because these foods are the collection of different range of plankton, small fishes, mollusk, crustaceans and other small aquatic organism. Natural food may belongs to either plant source or animal source. The natural source of food is considered as the quality content food for fishes and fish usually like to consume the natural food in the water body. The planktons small fishes, mollusk and crustaceans, worms, snails, mussel and others are the major source of natural food for fishes.

Planktons are the microscopic organism which can't propel themselves against water current instead moves along the current and drifts, including; Bacteria, algae, Protozoa small fish larvae and crustaceans and larvae of other sell fish. The planktons have very small size which drift in the water body, some have flagella and other do not posses flagella. Some planktons are capable of photosynthesis while others are not capable for photosynthesis. The planktons are single cell organism or multicellular organism depend on origin. Planktons are not belongs to any single particular family or groups rather are combinations of different group of organism as we mentioned earlier. There are following general classification of planktons;-

(a) Phytoplankton :- These planktons are capable of photosynthesis. Phytoplankton are the plant origin, called autotrophs. It is interesting to note that 70 percent earth oxygen produced by phytoplankton and oceanic photosynthetic grasses and plants. Phytoplankton include Dinoflagellates, Diatoms(*Fragilaria oceanica*), Cyanobacteria and Green algae. All of these are photosynthetic and drift in the water current. Phytoplankton are the good source of fish food but due to large accumulation of these planktons in the water cause death of aquatic organism like fish. These accumulations create oxygen deficiency in water and ultimately kill the fish. The phytoplankton are mostly primary food producer because they are photosynthetic organism which are generally single celled organism contribute this division.

(b) Zooplankton :- These planktons belongs to animal origin are called zooplankton. Zooplankton are heterotrophs and these planktons itself become a food for other upper trophic organism but these planktons feeds phytoplankton. Zooplankton are larger than phytoplankton which can seen by naked eye because in this planktons are mostly multicellular organism. These are very small arthropods larvae like larvae of shrimps, lobster, crabs etc. and include protozoa, crustacean, small fish larvae etc.

(2) Artificial / supplementary food :- This is a additional organic or inorganic food which introduce into water body for fast growth of fishes are called artificial food. These food are not naturally present in water which prepare in laboratories or industries and then introduced in the column of water body. Sometime lack of natural food in pond, lake or any water body create major food problem for fish which avoided by adding the artificial food to the water body. Artificial food has very nutritive value because these food prepare by adding different important molecules like essential amino acid, lipids and proteins etc. These important molecules helps the fish to get fast growth. Home made organic wastes also consider to be the artificial food.

Fish food divided into four category on the basis of fish need :-

(1) Main food :- Main food is the primary source of food for fish which depend on fish genetics and their habits. For example *Labeo rohita* fish is herbivorous and they feed plants origin food. The main food is exact what the fish used to feed regularly.

(2) Secondary food :- Secondary food is the additional or occasionally food for fish which feed by fishes when it available. Sometime fish feed the food which not normal they used to feed because that particular food occasionally founded.

(3) Incidental food :- When some food enter into mouth along with main food this termed as incidental food. Because the incidental food is not feed by fishes but it moves and entered into fish mouth through main food. For example, a fish feeds plants food but along with this food the animal source food also get into the digestive system, This is called incidental food.

(4) Emergency food :- This is kind of emergency or critical time food. This food is ingested by fish in order to survive because when fish have two option to die or survive thereafter fish eat any food whatever available in front of fish because the fish have to survive.

Food and feeding habits of fish are very diverse in nature. Feeding habits of fish depend on two major factors; first is genetics and second is environmental factors but both can fluctuate. For example, two group of fish one is shark and second is carps. Sharks being a carnivora feed animal source of food while carps have genetic to feed plant source of food. So both are different but might be changed in case of habits. Fish feeding divided into following type :-

(1) Herbivorous fish :- Herbivorous fish are those fish which feed mainly plant source food, mud and sand as well as algae. Mud and sand is not considered as true herbivorous food but fish feed along with other aquatic plant and algae. If gut content analysis shows 75 percent plant source food then fish confirm as herbivorous fish. Herbivorous fish eat plant source food so it require long and coiled digestive tract. These fishes are *labeo rohita*, *Cirrhinus mrigala*, grass carp etc.

(2) Carnivorous fish :- Carnivorous fishes are those who feed animal source of food. Carnivorous fish feed animal based food therefore these fishes easily get all the good percentage of protein and lipid than herbivorous fishes because animal generally stores all these essential protein and lipid. Hence these fishes are more active and efficient than those who are herbivorous. If 75 percentage of animal based food analyze in gut of fish, fish consider as carnivorous fish. These are *wallago attu*, *mystus gulio* etc.

(3) Omnivorous fish :- Several fish feed both type of food, plant source and animal source and also algae, mud and sand, rotifers etc. These fishes are called omnivorous because they have both origin of food in their gut content. In this type of food include several combination of food and also small larvae fishes. For example common carp, *heteropneustes fossilis*, *tor tor* etc.

(4) Plankton feeders :- Some fishes are feed only planktons includes zooplankton and phytoplankton. These are silver carp, catla catla and hilsa etc. The plankton feeder can either herbivorous or carnivorous because if the fish feeds zooplankton then called planktonic carnivora and similar for phytoplankton.

Feeding habits of invertebrates

Although we have described all feature and functional organs of invertebrates organism but here we delving into feeding habits of these invertebrates like prawn, lobster, crabs, bivalvia and cephalopods. The feeding habits of these organism can fluctuate on life stage because different life stages have different feeding behavior. In larvae stage these invertebrates prefer zooplanktonics kind of food than adult. Prawn are omnivorous invertebrate but in larval stage prefer only zooplankton because zooplankton are easily digestible than phytoplankton. In larval stage prawn are carnivorous plankton feeder but become omnivorous after juvenile stage.

Prawns have different stage of life like egg then larvae then zoea then mysis then juvenile and then finally adult. As per this stage of feeding, all these invertebrate have it's own habits of feeding. Lobster are omnivorous, bivalvia are also omnivorous but some species of these organism can consume different food.

Food and feeding in relation to age, season, selectivity and intensity in fresh water fishes

Food is the basic need of life which can fluctuate depending on the different factor. Food is not only the source of energy but also provide sustainable life. The food and feeding habits of organism of either fish or other animal can varies on following factors :-

(1) Age :- A fish developed from meroblastic cleavage. After development of fish from meroblastic cleavage, it further go down in different stages of development. Each stage of life of fish for example egg to larvae to fry to juvenile and then finally adult. On each life stage have it's own specific feeding habits, so feeding in relation to fish age can varies depending on fish species. Fish in the larvae stage mostly feed different food than their adult stage. A fish likely prefer easily digestible food as human do in their child hood. Because in larvae stage of fish have not developed well functional organ therefore fish in larvae stage prefer only zooplankton and plankton. Any species of fish like herbivorous, carnivorous and omnivorous all are depend on plankton as food source because these plankton have small size and easy to digest. Out of all type of plankton fish likely used to eat zooplankton because zooplankton easily digested without using extra enzyme and

time. After larval stage of fish, it switched on their genetics and their habits either herbivorous, carnivorous and so on. Hence fish feeding can fluctuate on the basis of age. Fish feeds many times because fish is in the developing condition so it have less developed digestive system.

(2) Season :- Fish food and feeding behavior can also varies in relation to season. Freshwater fishes are divided into warm water fish and cold water fish. Both type of fishes have adapted to it's environment. As we know that fish feeding habits can fluctuate on the basis of age but fish feeding also depend on season. Different season have different feeding behavior of fish because in summer season fishes likely used to feed the food also because in summer season fish metabolism occurs in high level. Due to high metabolism fishes also get high grown and size rapidly. These all depend on food therefore in summer season fish feeding become up but in contrast to winter, fish used to feed low quantity of food because in winter season fish have low metabolism rate. Raining season also influence the feeding habits of fishes because most of the fishes spawn in this season and after spawning fishes need more food because to cover the lost energy. Henceforth it considered that fish growth occurs high in summer and rainy season than winter.

(3) Selectivity :- On the basis of fish habits and their genetics, fish select their specific food whatever they regularly used to feed. For example a fish is herbivorous nature so they usually prefer photosynthetic and plant, algae and sand/mud source of food. The selection of food gives an idea about fish nature. Selectivity of food by fishes also varies on larvae stages because different larval stage have it's own nature to feed the specific food. Because of in larval stage the digestive organ and different other organ for proper digestion is not fully developed as much as it should required. So as simply selectivity of food is the way to find the good food for their proper growth of life.

(4) Intensity :- Fish feeding behavior provides a way to identify the various clue and knowledge about fish age, size, nature and many of interesting facts. The food and feeding behavior of fish is also depends on the intensity or amount of food consumed by fishes. The term Intensity refers the fact that how much amount of food ingested by fish to fulfill their stomach. Feeding intensity of fish is the best method to detect the fish gut content analysis. In contrast, After spawning period, fish feeding intensity slightly increased because in spawning period, fish lost all their energy and therefore they usually consumed in high ratio. Recovering those energy fishes need to eat much more food therefore feeding intensity increases after spawning. Feeding intensity of fish influenced by temperature, age, environment etc.

Food and feeding intensity of fish determine by **Gastro Somatic index or GaSi** . The equation can be expressed as :-

$$\text{GSI} = \frac{\text{Weight of Gut/Stomach Content}}{\text{Total Weight of Fish}} \times 100$$

Sometime is confusing to refers the term GSI because this term denotes Gonado somatic index.

Estimation of food consumption and utilization of food

Estimation and analysis of food consumption is the method to determine the gut content. Whatever food are present in the gut can be easily analyzed by these collection of methods. Stomach content collected by dissecting the fish specimen. The gut or stomach content analysis can be determined by following methods :-

(1) Qualitative method.

(2) Quantitative method.

(1) Qualitative method :- Qualitative method is the process of assessing the gut content by simply identification and classification of food item present in the stomach without using any additional tools and instrument. It also the simplest method but not useful at large range . Because it based on simple identification and classification of items of food molecule in gut, it is only used for determining the average type of food. As name indicate that it classify the food by their quality of food item. Due to it's simple method of determining of the food henceforth scientist not use nowadays.

(2) Quantitative method :- Quantitative method is true and useful method for determining the gut content because in this method use different other way to calculate the food item which present in stomach of fish specimen. In this method use different assessing method which are following :-

(a) Numerical method.

(b) Volumetric method.

(c) Gravimetric method.

(a) Numerical method :- In numerical method the gut content analyzed by simply count the number of food molecule. As it's name indicate number that it based on counting the number of food item present in gut of specimen. Simple compound microscope used for counting the number of food molecule. First of all the gut of specimen dissection and then analyze the food by microscope instrument. This numerical method is also four types which are following :-

(1) Occurrence method :- In this method occurs analysis of fact that the content presence analyzed by recognition of presentation of food molecule. For example a herbivorous fish have plant source food molecule. In this method only analyze the presentation of what food are in the stomach. Simple understanding, occurrence method is based on what food molecule are there in the gut.

(2) Dominance method :- In dominance method occurs the analysis of the fact that 'which food molecule are in high amount'. It deal with dominance of food, for example a fish is herbivorous so through this method get knowledge that fish have eaten more plant source food than others.

(3) Number method :- The counting of presented food molecule for example a fish which is omnivorous therefore this method provides the idea about that this fish have eaten different variety of food molecule.

(4) Numerical point method :- This is modified method of numerical method because In this method mainly focused on size of food in the gut of fish. It based on determining the common food in stomach of fishes.

(b) Volumetric method :- Volumetric method is type of the gut content analysis. In this method the volume of food present in gut is determined. Unlike numerical method which based on counting the number of food, it based on volume of food molecule in the gut of fish specimen. This volumetric method also three type :-

(1) Volumetric point method :- It is modified method of volumetric method. Like numerical method, it also measure the size of food and common food in gut but different from numerical method in contrast to identifying volume of food. One of the most notable thing is that it gives the volume number to food molecule. For example, on the basis of size and volume of food it awarded the food like 16, 10, 8, 5, 2.

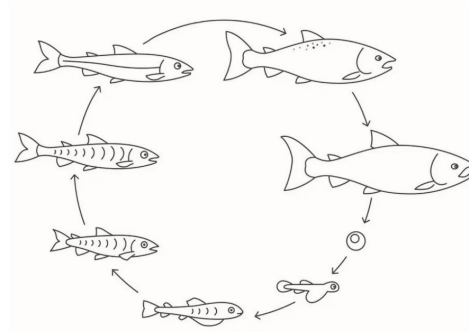
(2) Eye estimation method :- This is the simplest method because it estimate the food volume through naked eye of recognizer who working on it.

(3) Displacement method :- As name implies that it separate the different volume of food by displacement of the component in small sized filter container.

(c) Gravimetric method :- This is last method of determining the gut content analysis and also less used. Gravimetric method is based on measuring weight of food molecule present in fish gut. If fish gut content have been **moistened** so it have to dry first and then weight the food item for more accuracy. Moist food by water content removed then use this technique gives accurate result.

Growth of Fishes

Growth is bio-energetic process of change in length, weight and size of organism over certain time period called as growth. Over a certain time period, fish get increased in size and weight by different hormonal and homeostatic actions where these growth required energy which come from different food therefore growth is bio-energetic process. Growth of fish can be determined by several method.



Type of fish growth :-

- (1) Absolute growth :- Absolute growth as name implies that it is perfect and good growth of fish because in this type of fish growth the fish gain perfect growth according to their fish genetics. In this growth of fish occurs complete and proper growth of body size as well as different organs in the body of fish. Every organ of fishes developed in proper growth through this growth.
- (2) Relative growth :- Relative growth is quite different from absolute growth because in this type of growth, a fish growth compare to another life of fish growth. Obviously one fish life growth never similar to others. Relative growth is just a comparison to one another life growth.
- (3) Isometric growth :- Isometric growth refers the same rate of growth of whole body. In other word, All functional organ in fish body grow at same rate as body grows. Therefore due equal growth of whole body and it's organs occurs constant proportion throughout the life.
- (4) Allometric growth :- Allometric growth is just opposite to isometric growth because in this type of growth, the fish body grow at different rate as organs grows. There is no constant proportion of growth of fish body to it's organs. All body parts or organs growth according to their growth rate while body growth rate occurs at different rate than organs.

The cube law

The Cube law is the relationship between length and growth of body mass or volume. Cube law is the universal relationship between growth and length which says that size of fish increases, fish body mass or volume increase. According to cube law the length of fish increases as per growth of their body mass increases.

Which is :-

$$W=L^3$$

This cube law used in length-weight relationship. First, Le cren used the cube law to express the formula which is ;

$$W= aL^b$$

where; w is the weight and L is the length and a and b is constant.

Cube law is useful expression in determining the length-weight relationship of fish. This equation further modified and used in different methods. This mathematical expression gives the answer that why fishes mass and internal bodies fundamental increases along with the fish size increases. Cube law provides the fact that the large size building needed large thick fundamental.

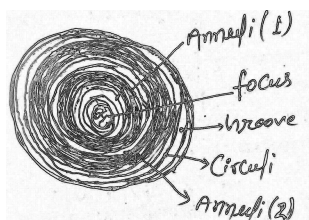
Determination of age and growth by indirect methods

The term Growth refers as increase in size and length which can be influenced by different factors. A fish growth can be determine by two method direct and indirect methods. In this topic we will see about indirect method of determination of growth. In indirect method there are several distinct sub-method used for determination of growth. The main purpose of methods to determine the growth of fish to get knowledge about fish age and their size and also weight. In indirect method contains following sub-methods :-

(1) Length frequency method :- Length frequency method which is a method of age and growth determination, is based on fact that fish size varies with age. For this method, collect a range of fishes and then plot all the fishes on graph analysis. For most of fishes, the spawning occurs once in a year which is differ from other non-spawning year and this spawning or breeding cause peak on graph. Each peak denote a year. Thereafter count the different peak of each fish growth and finally determine the fish age. This method used for only young fishes because breeding can influenced after adolescence of fish.

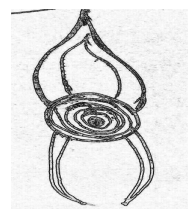
(2) Scales :- Scales has itself a great value, the scales also provide the great knowledge about age and growth of fish. Scales found on entire body of certain fishes except head, fins and also on ventral side of body. This method is very easy and legal method where first have to isolate the scales and then use to understand the different growth pattern on scales. In this method once a

scales removed from fish then visualize under the microscope to count the number of annuli which present on scales with different variations. Each annuli represent a year. A single scales consist of a focus on center part, Circuli is single rough tinny and fine circular structure and Groove is the gap present between each Circuli. Annuli is the rage of collection of Circuli which formed in very hifh growth of fish because in one annuli consist many numbers of Circuli which grew in growth period. Each annuli different from another annuli.

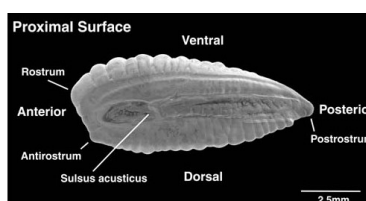


Simply, the counting of the number of annuli represent a growth period. It's a wide used method for determining the age and growth of fish.

(3) Vertebrae :- As we mentioned earlier in previous pages, vertebrate is an important part endoskeleton of fish. The fish vertebrae used for the determination of age and growth of fishes. Each vertebrae arranged in a pattern to form specific shape of fish body. Each vertebrae have unique structure; Nural spine and Hemal spine. These spine and arch are attached on center of vertebrae. The Center part of vertebrae is called as Centrum. Centrum have different lining of growth. As fish grow, several lines of growth appears on the centrum which shows growth of fish. The lines of centrum determine the fish growth and age.



(4) Otolith :- Otolith is an inner ear of fish which have primarily function of balancing the body posture in the water body and also the maintenance of fish position and movement. It present inside the skull of fish which also used to determine the growth or age of fishes. Otolith has small size in white in colour, formed by deposition of calcium carbonate. For the determination of age or growth of fish, first, otolith has to taken from the fish and then it adjust under the microscope to cut perfectly and find different layer of growth of fish age. The calcium layer lining deposited in each year mostly in summer season can easily visualized under microscope. These lining of calcium salt shows the age and growth of fish.



Estimation of fish age and growth by direct method

Estimation of age and growth of fishes by direct method involves Marking and Tagging process. In this method, first have to caught the fish from fish ground and then use this technique to determine. Tagging and marking is the method which occurs only in **controlled condition** place of fish because for this method fish have to identify again after a period of time therefore the condition required like this. First select the pond or whatever the source of fish place and type of fishes for determining the age and growth of fish and then caught them by different special gear and craft. This method of determination of age should required fast and instant insertion of tag or mark on fishes because mapping and tag have to done very fastly then delivered the fish into water. Already made tags and marks used for this method which just insert to fishes. After inserting the tag and mark, fish released into water column. This method have some disadvantage that most of the tagged fish not re-catch during recapture of fishes and also some of the fishes easily get prayed because of stress and infections of tags. In this method involved following distinct method :-

Fin clipping is the method of tagging and marking where the copper like wire (have specific information) inserted into the base of the dorsal and anal fish and then release into water. When those tagged fish re-caught after certain age then determine the growth of fish. This method have verity of disadvantage because the chance of fishes that can come back in re-catch is very less that's why this method perform on large number of fishes at once. Most used tag is Peterson tag.

Pit or passive integrated tag is also widely used tag because this tag mostly inserted into the skin which produce certain type of frequency. It is also radio tag with small size. There are so many other tag that are used for different factors like Colour, parasite, chemical and physical tag and marks are used for this method.

Length weight relationship

Length weight relationship as name implies, it's a interrelationship or co-relationship between length of fish and weight of fish. The Length weight relationship is a mathematical expression by which we used to get knowledge about how fish size influenced by it's weight and vice-versa. This mathematical method used to determine the growth of fish regarding to size of fish. Length weight relationship is universal relationship between length of fish in centimeter to weight of fish in gram.

Length weight relationship express as by using cube law ;

$$W = L^3$$
$$W = aL^b$$

Where ; W is the weight of fish in gram.

L is the length of fish in centimeter and 'a' and 'b' is co-efficient constant.

This equation can be log transformed by Le cren and express as ;

$$\log W = \log a + b \log L$$
$$\ln W = \ln(a) + (b) \ln L.$$

The main purpose of the length-weight relationship is to find the length of fish accordingly to fish weight. For example if a fish is about 36cm therefore at this length what should be the weight of fish and vice-versa. This length-weight relationship provide to answer this question.

Length weight relationship is mathematical equation so the data calculated by using one concept that if the value of **b** become more than three(3) then the fish size increases by isometric growth but if the value of **b** is less than three(3) then the fish growth occurs by allometric growth. There are two condition that in allometric growth that the value of **b** can be greater than 3 or less. If vale is greater so fish growth behaves like positive allometric growth, if less vale occurs then negative allometric growth.

Ponderal index and relative condition factor

Ponderal index so called condition factor is a universal factor for condition of fish in water. Ponderal index is important tool for biologist to understand the health of fish. This index of fish can be used to asses the total health condition of fish. Ponderal index is the study of determination of the total well being, shape and condition of fish in the water body. The ponderal index of fish denoted by K ;

$$K = \frac{W}{L^3}$$

Where W is the weight of fish

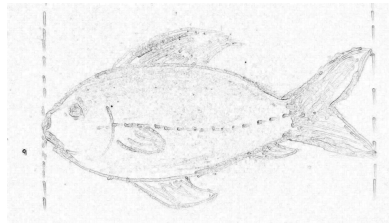
L is length (in cube)

This equation shows that the ponderal index is the ratio of weight of fish to length (in cube) that stated the condition and shape of fish. This index multiply with 100 to get average equation ;

$$K = \frac{W \times 100}{L^3}$$

The ponderal index used for determining myriads of observations but one of the major factor calculated by this index is the presence of food and health of fish in the water body. First, the fish collected from ground then use this equation on it to get average value of k. This index not only provide the importance of total well being of fish but also provide the data about the fish growth.

Biologist also used this method to know about the food presentation in pond, river etc. If the value of K is greater thereafter assume that fish feeding good food in pond so overall pond have great abundance of food.



Relative condition factor is the ratio of observed weight of fish to the estimated weight of fish. The relative condition factor is modified form of ponderal or condition factor. Relative condition factor can represent as ratio of W' to W of fish weight. These all factors and index used for estimating the health and condition of fish. Sometime researcher also use to find the abundance of food in pond.

Relative gut length and gonado somatic index

Relative gut length is the ratio of total length of gut to the total length of fish is termed as relative gut length or RGL where we do not multiply by any digits. Relative gut length used to estimate the nature of fish like herbivorous or carnivorous. For example a fish which have smaller gut length indicate this fish is carnivora and so further investigations. Therefore on the basis of RGL, we can find the nature of fish easily but obviously there are so many other method to estimate the nature of fish.

Gonado somatic index (GSI) which is differ from Gastro somatic index in contrast to weight of gonads of fish is divided by weight of fish. Because gastro somatic index used to calculate the gut content while the gonado somatic index used to calculate the active stages of gonads or also the spawning and health of fish gonad. Gonado somatic index is the ratio of weight of gonads to the total weight of fish is multiplied by 100 is refers as GSI of fish.

Type of reproduction

A organism survive on this planet since millions of years and each organism produce their next survival offspring by a process refers as reproduction. Reproduction is the passing of the genes to their next generation. The term reproduction refers that it's a way through which organism produce their own offspring or new individual which is more capable to challenge the current environment and therefore they survive in the new generation. Reproduction is divided into two major category which is (1) Asexual and (2) Sexual reproduction. In asexual reproduction the organism produce exact similar copy of their parents therefore the offspring is genetically identical to their parents. Nearly all fishes sexually reproduce but one of the fish species called amazon molly are reproduce

asexually. **Amazon molly** reproduce by parthenogenesis which is a kind of asexual reproduction, amazon molly produce exact copy of their mother and therefore the all offspring or fishes are always female, male never born. The interesting fact is that at the fertilization time the male fish are required but the nuclear contribution of male does not occur and henceforth the gamete of female or amazon molly are always diploid in nature. There is a question in our mind that how this happens ? Because male amazon molly never born but male requires at fertilization, this is answered by one fact that other fish species from same genus and family involves in it and stimulate the egg cell to delving into the next embryonic development without contribution of male fish. Despite of fact that parthenogenesis is a type of asexual reproduction, it is more accurate to write here that parthenogenesis is incomplete sexual reproduction because gametogenesis still occurs in this process. The sexual reproduction in fishes provides great variations and capabilities to sustain their life in the environment.

In Reproduction of fishes occurs two type of fertilization; External fertilization and Internal fertilization. Because fishes are hydrocordates therefore water serves as good medium for external fertilization but some fishes for example, Sharks internally fertilize the gamete because shark has clasper which is used for sperm transfer from male shark to female shark.

Type of reproduction in fishes:-

(1) Bisexual or Gonochorism reproduction :- in gonochorism, fishes have separate sex. The fish have either male reproductive system testes or female reproductive system ovary in separate fish body. The sex of fish decided by chromosome and persist throughout the life. The hermaphrodite is opposed to gonochorism. Gonochorism or bisexual fishes possess single reproductive system in either male fish or female fish separately.

(2) Hermaphrodite :- Hermaphrodite are those organism which have both male and female reproductive organ in the same individual body. The term hermaphrodites refers the organism which possess both type of reproductive organs that means have both testes and ovary in the same fish body and therefore the fish can produce both gametes. In fishes, hermaphrodite is very common and specially for small and perch like body form fishes but data can varies according to species of fishes. Hermaphrodites fishes can be reproduce by itself or others. Hermaphrodites in fishes are following type :-

(a) Synchronous or Simultaneous hermaphrodites :- It is a type of hermaphrodite where the fish have both male and female reproductive organs in the same body of fish and the both gonads are functional at the same time. In the simultaneous hermaphrodites both testes and ovary mature and releases their gametes at the same spawning time but the self-fertilization occurs rarely. The produced gametes at the same spawning time by simultaneous hermaphrodite fish used to fertilize the other gametes of the same fish species. Simply, both gonad present in same body and both active at same spawning time. For example, some species of clown fish, sea bass and other coral reef fishes.

(b) Sequential hermaphrodite :- In sequential hermaphrodite the fish possess both male and female reproductive organs namely; testes and ovary respectively in the same individual fish body but only one gonad is active at single spawning time. At maturity or spawning period the only one gonad is

functional and produce gamete (Either male or female). Both reproductive organ can't produce gamete at the same spawning period of time. Therefore this sequential hermaphrodite are two type:-
(i) Protandry:- If the fish start it's life as male that means fish first mature as male but then changed into female sex is termed as protandry. The term protandry refers the "before male" is condition where fish start it's life as male but due to some factor like lack of opposite gender in fish school or seasonal behavior changed into female sex in their life. For example, some wrasses and some species of clown fishes.

(ii) Protogyny:- if fish start it's life as female that means first maturity as female but after then changed into male sex are called protogyny. The term protogyny refers the before female but then turned into male. Most of the fishes are protogyny type of hermaphrodite. For example, most of the clown fish species, gobies and other species of coral reef fishes.

(c) Bi-directional hermaphrodites:- This is a third type of hermaphrodite. In this hermaphrodites fishes also have both male and female reproductive organs in the same fish body but the fishes are capable to turn their sex more than one time, for example, if fish first mature as male but due to some factor he changed into female sex but again they can tune back into male sex therefore this bi-direction fishes have ability to change their sex more than one time. For example some species of gobies.

(3) Parthenogenesis :- parthenogenesis is a unique type of reproduction in fishes. Parthenogenesis is a process of reproduction where new young one develop through without fertilization of gametes nuclei. It is little confusing but the new fishes developed from without fertilization of their egg. It mostly seen in insects and fishes. Parthenogenesis is considered as a type of asexual reproduction but more accurate to say incomplete sexual reproduction. It has two type:-

(1) Natural parthenogenesis :- In natural parthenogenesis the fish naturally produce from without fertilization of fish eggs nuclei. In this type of parthenogenesis, there is not involvement of any additional factor to proceed instead it's occurs because of fish genetics and their nature. As name suggest that there is complete development occurs of individual by natural parthenogenesis. This type of parthenogenesis are two type

(a) Complete natural parthenogenesis :- In complete natural parthenogenesis occurs complete development of new young one through without fertilization of fish gamete nuclei. Complete parthenogenesis is also refers as a true parthenogenesis.

(b) Incomplete parthenogenesis :- In incomplete parthenogenesis, there are two reproductive phase
(1) Sexual:- in sexual phase the new individual form from fusion of nuclei of gametes but this fusion always form females. (2) Parthenogenic:- in parthenogenic phase occurs no fertilization of gametes and their nuclei hence the egg develop always as male. Mostly found in insects.

(2) Artificial parthenogenesis :- The artificial parthenogenesis occurs by adding some factions. Artificial tools and technique used to proceed this reproduction because in this method provide suitable parthenogenic condition to fish for develop the progeny without fertilization. There are so many different factors are there like temperature, chemicals, electric shock, Ph and ultra violet light

etc. The main purpose of this parthenogenesis is to provide the rapid development and also protect and conserve the rare species of fishes.

Male fish reproductive structure and function

As we discussed about male and female reproductive system in previous pages, male fish have pair of elongated testes near to kidney which attached to mesorchium, a type of connective tissue. The pair of testes classified as anterior and posterior part but the anterior part is much involved in the formation of sperms but the posterior part largely contribute to store and provides passage for sperms. The fish testes shape and size varies accordingly to fish species and maturity stage because at the time of fish spawning the testes become thicker and heavier in weight. The fish testes possess two type of seminiferous (1) seminiferous tubule and seminiferous lobule. The most of fishes have seminiferous lobular type of testes as we discussed earlier. The testes has seminiferous lobule, interstitial cell or leydig cell. The seminiferous lobule have two type of cell one is somatic sertoli cell and other is germinal epithelial cell called as primordial cells. The leydig cell which present outside the lobule is responsible for the formation of secondary sexual characteristics by formations of androgen hormones controlled by FSH and LH. The sertoli cell in lobule provides nourishment for developing sperms. The germinal epithelial cells formed into primordial germ cell by mitosis in embryonic development. The primordial germ cells at the time of formation of gamete, start mitosis to form spermatogonium cell which is diploid in nature. The spermatogonium cell also start mitosis to increase the number of gametes cell. The spermatogonium cell forms many spermatogonia by many multiple mitosis. For sake of simplicity, one of the spermatogonium grow and changed into primary spermatocyte with diploid number of chromosome. The first meiosis occurs on primary spermatocyte to form secondary spermatocyte with haploid chromosome because meiosis-1 is the division of homologous chromosome. Then meiosis-2 proceed on secondary spermatocyte to form spermatid. The one primary spermatocyte forms total four spermatid's. Spermatid mature and changed into complete sperm. Once the sperm formed, it releases from the lobule to common passage for sperm duct and then finally expelled out of the body.

There are following stage of male reproductive cycle:-

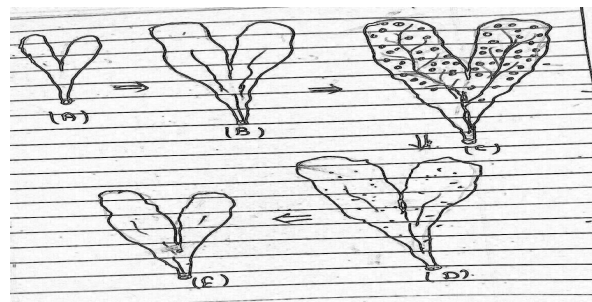
(1) Resting phase :- This is the first stage of reproductive cycle in male fish. Resting phase as name implies that there is no formation of any sperm cell occurs in this period. In this phase the gonads is in it's inactive state and the size and shape of gonads in resting phase is almost contracted, translucent and small with thin structure. Because the resting phase refers nor formation of gametes therefore this phase have no great role in spawning period.

(2) Preparatory phase :- In This phase occurs the formation of sperm cells. This phase known for spermatogenesis where the sperm cell prepare from spermatogonium cell by spermatogenesis. This phase, when the germinal cell start to form the sperms, the shape and size of gonads also influenced because it's a active state therefore gonads are increased in weight and size.

(3) Maturing phase :- After formation of the gametes cell, the cell mature from spermatid to complete functional sperm because in preparatory phase the sperm are not directly formed therefore in this phase the maturation occurs on it. The maturation proceed by spermiogenesis process. In this phase the spermatid cell mature into complete active sperm cell which almost ready to fertilize the egg. This phase occurs just before the spent phase the the gonads in this phase seems very thick and heavy in weight.

(4) Spent phase :- The final stage of sperm release is the spent phase. spent phase is the phase of spawning because the formed sperms are release in this phase. This phase is the releasing phase so the heavy weighed gonads slightly become reduced in shape and in mass. Then after the gonads or testes becomes small in size until nest preparatory phase start.

(5) Post spent phase :- Post spent phase is the last stage of this reproductive cycle. This stage going to enter into again resting phase. The gonad again become thin and small. As you see in the diagram below :-



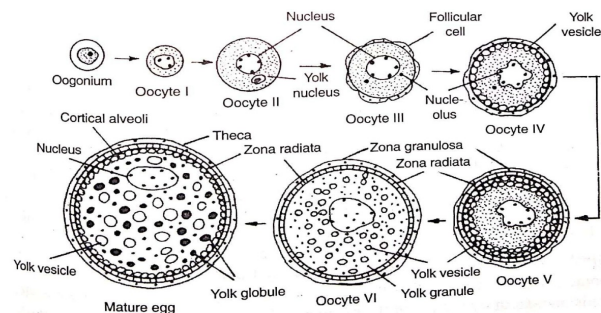
Female fish reproductive system

Female fish has pair of elongated ovaries in the dorsal side of the body near to kidney. Both ovaries attached to coelomic body with help of mesovarium layer. The shape and size of ovary depends on type of species and stage of fish reproductive cycle. As I mentioned in previous pages, the female fish has ovaries wall which covers the ovary and inside the ovary consist many ovarian lamellae which separate the ovarian lumen or stroma to site of formation and maturation of ova because these lamellae made of basement layer within which the egg cell forms and grows. The egg cell forms from primordial cell. The formation of gametes occurs in four stage, first stage is called as primary growth stage where the primordial cell start mitosis to form oogonium cell. When after appropriate number formed then oocyte developed into primary oocyte. In the primary growth phase the primary oocyte also start meiosis-1 but arrest in prophase. This primary growth phase occurs in non-spawning phase that means when spawning season is not proceeding. When season of spawning begin as a result the secondary growth phase start completing the meiosis-1 and then form one polar body and one secondary oocyte. The secondary oocyte also starts meiosis-2 but it is arrested in metaphase-2. In mid-between this process the follicles cell also arranged on the cells like granulosa cells and theca cells. These cells are responsive for formations of estradiol hormones which produce secondary sexual characteristics and yolk proteins. Then third stage called vitellogenesis occurs, in this stage the vitellogenin protein with lipids, phosphate and carbohydrate accumulate in the egg cell to form yolk protein. The liver cell forms this vitellogenin protein where the vit-genes forms this yolk protein but

after post translation the vitellogenin lipidated and phosphorylated and also glycosylated. The vitellogenin associate to these additional molecule to form verities of yolk protein form but the most prominent form is being with lipid. Also many vitamins and metal ions incorporated into this vitellogenin protein.

Finally maturing phase comes and complete the arrested stage of meiosis-2 of secondary oocyte, as a result one polar body and one complete mature oocyte formed. At the ovulation time the egg released into the ovarian lumen and then pass into the next oviduct for releasing outside the body.

There are three type of ovaries found in fishes one is Gymnovarian second is secondary gymnovarian and cystovarian. For more detain description, see previous pages about this topic.

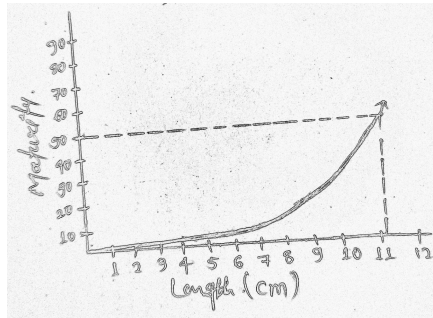


The female reproductive cycle :-

- (1) Resting phase :- Like male reproductive cycle, female fish reproductive in this phase occurs inactive. The fish ovaries in this phase is thin and reduced in structure. The gonad is translucent and thin with contracted structure. The size and shape of gonads also small and compressed.
- (2) Preparatory phase or early maturing phase :- In this phase the ovaries become slightly larger in size and increased in weight. This phase also known for formation of oocytes. The formation of oocyte get started as fish enter in this phase. The oogonium cell start forming oocyte by subsequent division of cells.
- (3) Advanced maturing phase :- In this phase the formed oocytes matures and capable to fertilize. Maturation proceed on the formed oocyte only when estrogen and vitellogenin inserted in it. It's a last phase of maturation so the shape and size of gonads is very thick and heavy.
- (4) Spent phase :- at spawning phase the ova released and go for fertilization but the ovary again entering into thin and compressed stage. This is the releasing phase of egg were the egg cell expelled out of the body which is controlled by hormones. Because it is linked to spawning phase therefore the spent phases also considered as part of spawning period.
- (5) Post spent phase :- This is occurs after spawning period when all the egg ejected. Therefore the ovary becomes reduced and low in weight.

Size at first maturity

Fish is a cold blooded creature which have fins for it's locomotion instead of limbs which is characteristic of tetrapoda. As we mentioned before that a fish have different type of reproduction and reproductive system like testes and ovary in male and female fish respectively. The term size at first maturity refers the capability of fish to spawn or reproduce at what length of fish. The size at first maturity can be defined as "The length of fish at 50 percent maturity". That mean you can understand the concept by this diagram ;



As you can see in this image that there is a fish which get first maturity or more than half at 11 cm length. This 50 percent maturity is the first maturity and the length at which fish attain the first (50 percent) maturity is called as size at first maturity of fish.

Note that the maturity of fish can varies and therefore some fishes attain sexual maturity at very early stage of like like some Perciformes fishes attain sexual maturity just after some months while in some other fishes like tuna and sharks they attain after years. Here if you notice that for different fishes have different length at first maturity because some fishes get 50 percent maturity only at 5 cm while some get it at 20 cm and more, maturity of fish varies on species to species.

Fecundity and estimation of fecundity of fish

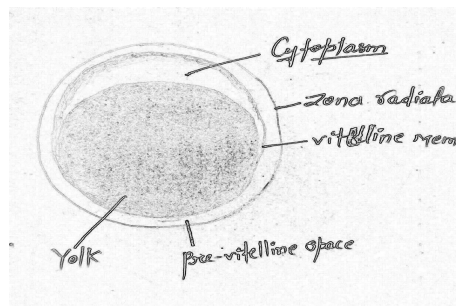
Fecundity is the number of ova or eggs released by female fish per spawning season. The Fecundity of fishes varies according to the fish species type and different other environmental factors. Fecundity estimates the number of eggs pawned by fish in any particular fish pawning period. If the number of eggs released by fish is not appropriate to fish body size then the fish consider as underdeveloped or unhealthy. The estimation of fecundity is done by following method :-

(1) Gravimetric method of fecundity :- In this method the fecundity of fish is determined by the ratio of ovary mass to the oocyte density. The oocyte density is also defined as the number of ova per unit density of the ovary tissue.

(2) Volumetric method :- It is more similar to gravimetric method because only difference is that the fecundity determined by using volume instead of mass of ovary .

Ova of fish

The fish ova is membranous bound gamete cell which responsible for development of new generation of fish. In ova or unfertilized egg of fish contain large amount of yolk because this yolk content in egg provides the nutrient source for development of fish. Despite from yolk there are several molecule which help in differentiation of cell and development of fish. The shape and feature of each egg depends on nature of fish egg because some egg has micropyle (especially in teleost) while other don't. The outer most membrane of egg of fish is Zona radiata but sometime there is a confusion to understand because the term zona radiata can also replace by zona pelucida. This membrane provides protective barrier. Next membrane is vitelline membrane which is present just near to plasma membrane of fish egg. The space between vitelline membrane and outer membrane is called as pre-vitelline space. The content size of yolk varies greatly on species and type of egg like demersal and pelagic.



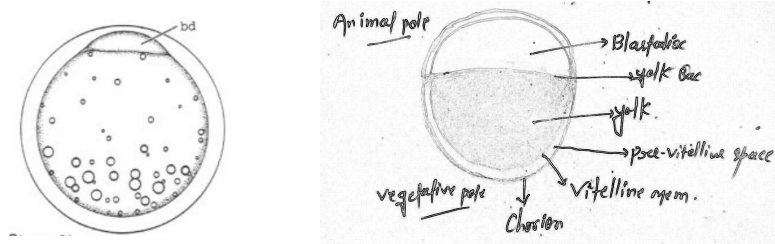
The great portion of Cytoplasm or ooplasm of fish is contributed by yolk of fish.

Embryonic development of fish

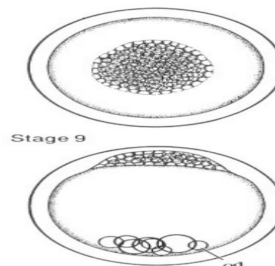
As Theory epigenesis explain that every organism develop from their simplest form of life or egg to very complex form of life or adult by differentiation of cells. After fertilization of matured fish ova by their same species sperm cell therefore developed into egg or zygote. The formed zygote then mature and get differentiated into many to form larvae. The term embryonic development implies the fish egg is developed into the complex adult system from it's embryo. The embryonic development of fish have following stage :-

(1) Zygote stage :- Zygotic stage is the first stage of fish development. After fertilization of gametes, fish egg developed into Zygote. In this stage the fertilized egg evolved in complete zygote. There are two pole in each egg cells, one is animal pole and second is vegetative pole. Each pole of egg are present on opposite to each other. In this zygotic stage, the egg which has consist cytoplasm and nuclei are separated and move toward the animal pole and the large portion of yolk also separated in the vegetative pole. Both male and female fused nuclei moves toward the animal pole

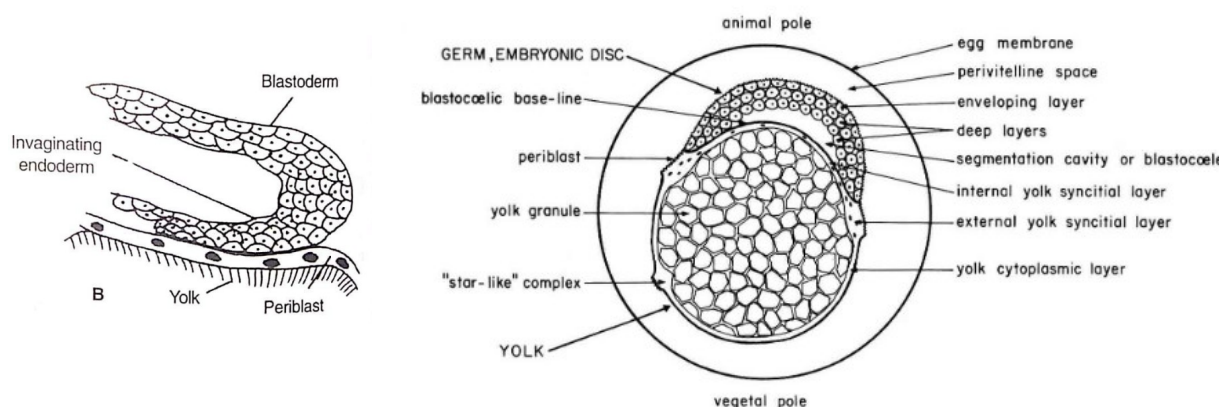
where it forms blastodisc. The blastodisc is the precursor of all cell division and it's almost cap like structure on the animal pole.



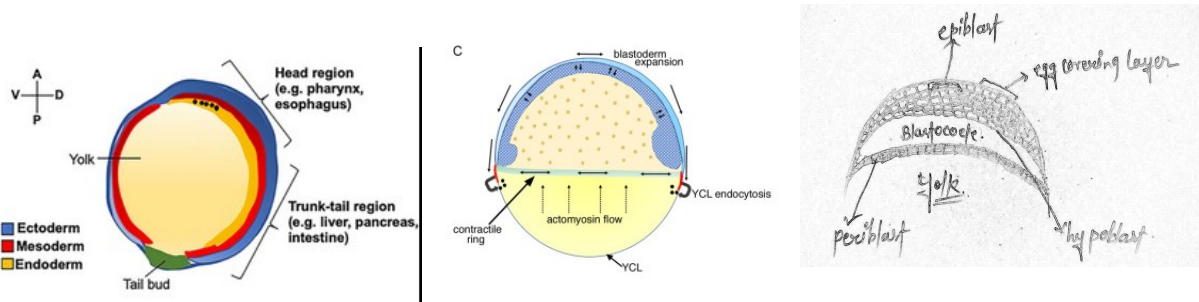
(2) Cleavage :- Cleavage is the second process of development of fertilized egg into it's multicellular condition. In cleavage, series of mitotic cell division proceed on blastodisc where the number of chromosome still occurs in constant. Due this several mitotic division of blastodisc forms blastomeres. In fishes the cleavage is meroblastic that means the fish egg do not divide entirely rather cleavage only occurs on blastodisc portion not on entire egg cell. Cleavage is important process in all stage of embryonic development because this is the stage where the cell are divide and form multicellular structure. In cleavage stage one blastodisc at animal pole undergo in mitosis to divide into two equal cell called blastomeres. Next to this, each blastomeres further divide itself and form more blastomeres by mitotic cleavage. At sixth mitotic cleavage forms 64 blastomeres but after this stage the blastomeres now collectively called as blastoderms. At six mitotic cleavage form 64 blastomeres or collectively called **Blastoderm** are also known as morula. Further, morula (64 blastomeres) cells divide upto many blastomeres or Blastoderm.



(3) Blastula :- Blastula occurs after the morula stage when more than 128 blastomeres developed. In blastula the blastoderm extend on the yolk and start forming blastocoel, a small space formed between blastoderm and periblast. The periblast is the small layer on yolk sac which separate the yolk from blastoderm and provide the energy to developing cell from yolk. In blastula the blastomeres divides multiple times to reach appropriate number of cells. The blastoderm layer start forming hypoblast by invagination into the blastocoel. The time required for the formation of several blastomeres can varies with species to species.

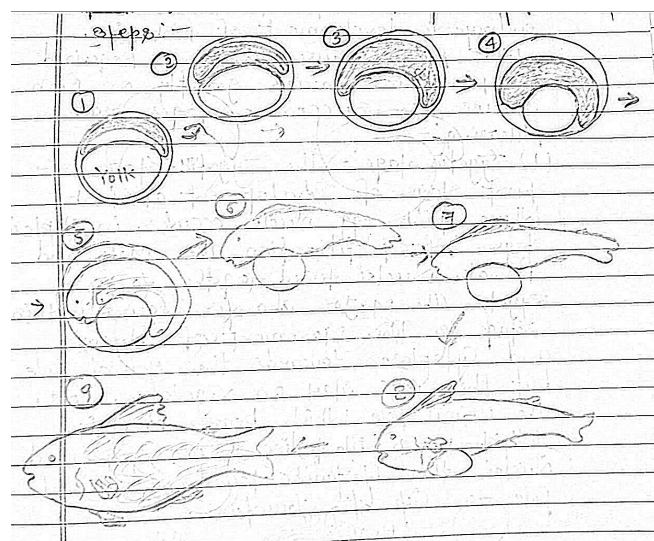


(4) Gastrula :- Gastrula is the final stage of embryonic development but after this stage occurs one of the organogenesis where the different organs formed on the basis of this divided cells. In this stage of embryonic development the three germ ectoderm, mesoderm and endoderm layer are formed. The epiblast layer forms germ layer namely refers as ectoderm and mesoderm but endoderm form from hypoblast layer of blastoderm. The blastoderm extend on yolk reservoir to form straight fish shape with help of germ layers. First, the blastoderm form ring layer around the yolk but leaving small part at vegetative pole.



As you see in these diagram, the ring layer on yolk which have ectoderm, mesoderm and endoderm but at the point of vegetative pole remains free as small portion. At the end of this stage form nerve cord and many body parts.

(5) Organogenesis :- After series of formation of layer and body form, in organogenesis the vital organs like heart, notochord development, brain, liver, kidney and other important organs develops. After complete organogenesis the larvae of fish get hatched from egg and freely float in water or also stay on bottom. The time of egg development from fertilization to hatching can varies per species to species. After period of hatching, the spawned fish larvae get participate in series of development and start metamorphosis.



Type of eggs of fish

The size and shape of fish egg are divers in nature because different fishes have different type of egg on their genetics and habits. Even some fishes have different type of shape of egg like of sharks because in shark and skates fish egg posses filamentous thread where the egg contain in pouch like structure. The type and classification of egg are greatly varies, these are following type:-

(1) The type of fish egg on the basis of location in water column

(a) Pelagic egg :- Pelagic eggs are those fish egg which are predominantly found in pelagic part of water. This egg have different feature like these egg haven't adhesive membrane to attach. therefore present in floating condition in water. Pelagic egg are transparent and small in size which consist either large yolk or small vesicles type yolk. Density of pelagic egg is less than sea water. This type of egg found in mackerel, herring etc. the composition of yolk in this egg is less therefore it floats.

(b) Demersal egg :- This type of egg have well developed adhesive membrane on outer layer of egg which help it to remain attached to any object or also on sediment. These egg have large size and high lipid or oil content therefore it get sedimented at bottom. This type of egg are also two type ; adhesive egg means have adhesive membrane and always found in the attached state while non-adhesive egg are those egg which haven't property of attachment but due to heavy weight stay on ground on bottom like salmon eggs.

(2) The type of egg on the basis of yolk content :- The fish egg have verities of content but distribution of their material is not similar in all fish egg. Fish egg is macrolecithal meaning that egg consist large portion of yolk. The fish egg divided into two category

(a) Homolecithal egg :- Homolecithal egg consist evenly distributed yolk or yolk nutrient found in many small droplet form. Example are echinoderms.

(b) Heterolecithal egg :- Yolk are not evenly distributed in ooplasm that means the yolk is attained their large single size. Example, bony fishes and most other fishes.

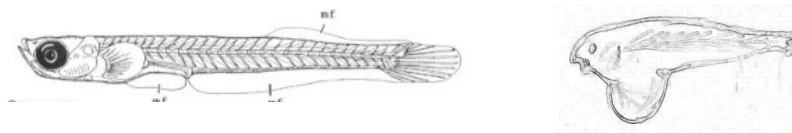
Heterolecithal divided into two group (a) Telolecithal meaning that yolk content present at vegetative pole or tail region rather than center. (b) Centrolecithal have yolk at center of ooplasm of fish egg.

(3) Type of egg on the basis of shell :- Fishes have non-cleidoic egg meaning that fish egg haven't outer shell of any calcium carbonate but present external layer to protect the egg but the membrane is not enough as shell.

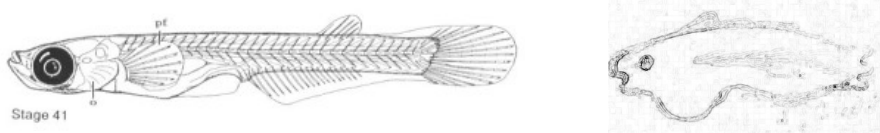
Metamorphosis of fish

As we know that fish is cold blooded aquatic creature that are mostly egg laying but some are also live bearer. After hatching the new egg of fish larvae unable to swim but they can float along with water movement. These larvae feeds only easily digestible foods and planktons. The change in structure and body function of fish after hatching occurs by special process called metamorphosis. Metamorphosis of fish are following steps :-

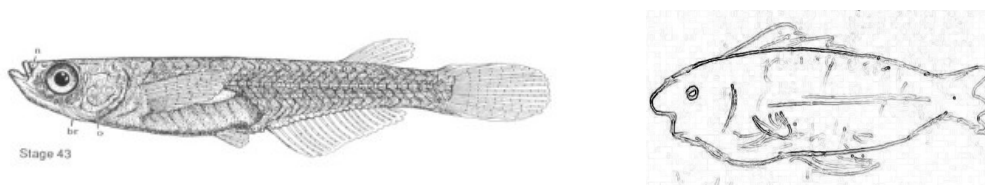
(1) Stage-1:- In the first stage of metamorphosis, the fish have undeveloped fins and body which are not able to swim. The yolk sac easily seen in this stage. The main change in the fish larvae is reduction of the size of yolk content, dorsal fin spine develop and attaining straight size of fish. The whole body is looks transparent and whitish in colour. The Digestive system is also undeveloped therefore the larvae in this stage feed mostly zooplankton and small digestible food.



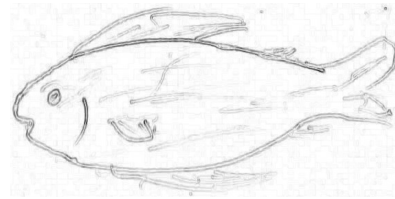
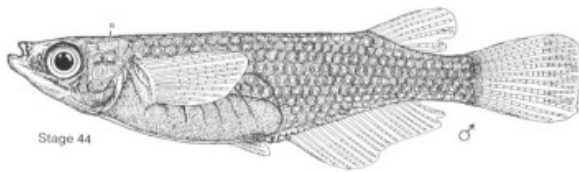
(2) Stage-2 :- The second stage is also the continuous stage of the fish development because this stage refers as the larval fish development. The major changes occurs in this stage is enlargement in size and the black eye get it's colour. The spines of fins still occurs in development. The body colour still transparent and whitish. The major changing in this stage is change of head region and caudal region.



(3) Stage 3 :- This stage called as middle stage of the metamorphosis and the major change occurs in this stage. In this stage, the body colour gained according to their genetics of fish. The Fin of larvae fish get developed, dorsal caudal and pectoral fins are the major. The digestive system also become functional. Now fish can swim and feed the foods, the fish also influenced in size.



(4) Stage 4 :- The yolk content completely disappear in this stage and the fish actively swim in water body. The fish fins attained it's colour and the body colour of fish also covers on whole. The larvae called as fry after this stage because the fry stage is more developed stage than larval where the fish able to feeds it's own and can swim for some distance.



Metamorphosis of fish varies greatly because all fishes have different base of genetics therefore the express different metamorphosis. The foods habits of fish at larvae stage also influenced with environment and nature of the fish.

NOW WE'RE DELVING INTO THE NEXT PAPER

Inland Capture Fisheries

Importance of capture fisheries of the world

The term capture fisheries refers to the fisheries of commercially, ornamental and recreational purpose. The term Inland refers as the fisheries performed on land (Freshwater and brackish water) rather than marine water. Overall the inland capture fisheries are capture and culture of fishes which occurs in freshwater and some time in brackish water for commercially value and also for some other purposes.

The importance of capture fisheries of the world are following :-

(1) Food security :- Today's population is really overwhelming which needs great source of food. The fish as food is such a great growing industry to supply food for range of population. The Inland fisheries is an important fisheries for food value in rural as well as in urban area. Because it's a chief source of food as well as with verities of nutrients, everyone can easily take it. The inland capture fisheries also enrich with different valuable nutrient like amino acid, proteins etc. Inland capture fishes are good example of food resource fisheries which performed in pond, river, tanks etc. The Inland fisheries contributes their beneficial role in making good nutrient supply in rural area specially. Therefore Inland capture fisheries have very much role in food security.

(2) Economy :- Because fish is the new growing industry to provide food for immense number of peoples. The inland capture fisheries contribute good economy source. Recent study reveal that the contribution of economy to indian GDP varies accordingly but the fish industry is growing source of economy.

(3) Employment :- Fisheries is one of the best employment and job sector. Specially inland capture fisheries are the best opportunity of job because of various kind of management, food and different scientific study have been developed. It provides not only about the culture and breeding of fish but also provides the scientific study on fish to increase the food value and different other beneficial importance. Now day's this sector evolving very rapidly due high demand of job and also because of food securities.

(4) Ecosystem :- Fish contribute myriads of importance for building new and better ecosystem. For example Gambusia, a mosquito fish is known for controlling the growth of mosquitoes from the water bodies.

International fisheries commission

International fisheries commission is the Fisheries management and conservative commission which first built as a treaty between Canada and united state of America. The international fisheries commission fall under the general fisheries commission where the commission classify on the basis of their function of conservation for example, marine fisheries commission, inland fisheries commission. The main purpose of the international fisheries commission is to provides protection and conservation of fishes. It established to manage and protect the deep sea fishes as well as some threatened fishes and also for economical important fishes. International fisheries commission is based on the type of fishes for example, Tuna fisheries commission, pacific fisheries commission, Atlantic fisheries commission etc. These fisheries commission conduct great role in protecting the certain fishes like; salmon, tuna and it's related species. The fisheries commission for conservation of tuna is termed as "**International fisheries commission for conservation of Atlantic tunas**". Similarly for salmons and many other fishes. International fisheries commission or IFC is also work on biological phenomenon of protecting the great ecosystem of deep sea and the fishes (or some other threatened animal in ocean) which under threatened list.

The international fisheries commission manage the threatened and some deep sea fishes and it's life. So this commission focused on some rule by which the deep sea fishes and others can protect for future generations. In this commission involved several maritime countries to protect the certain fishes But the management and protection of fishes is the prime thing of this commission, it also support the food and better environment of fishes. **The function of international fisheries are following :-**

(1) Conservation and management:- Due to verities of environmental and physical factors, some fishes becoming threatened. As we discussed that IFC is one of the commission which care about those fishes which now becoming rare or threatened in ocean. Because of overfishing, the certain fishes or deep sea fishes are now getting addressed in threatened list of fishes. The international fisheries commission provides different rules and regulation which merely focused on the fact that how we can control the overfishing and protection for those fishes which going to be rare. The international fisheries commission have some rule for example, Gears restrictions, only allowed those gear which may not harm fish life as much. Secondly, rules also states that fishing restricted after certain nautical miles like 200nm. However, IFC do not restrict the fisheries from inshore fisheries. The IFC manage all the way through which fishes or threatened fishes can be protected. These all the conservative mechanism provides good beneficial way to conserve the fisheries.

(2) Scientific research and effects:- The scientific research of fisheries provides verities of knowledge about fish life including reproduction, feeding behavior and several others. The IFC which have been treaty between Canada and U.S. but also many maritime countries participated as per their rules. The major scientific study focus on the life style of these deep sea fishes. The IFC also manage the research on fact that how to conserve the threatened species of fishes and how

enhance the fisheries. All the stoking, fish population and ponderal index are calculated by painstaking research on these fishes which largely fall under this commission. In this scientific study of fisheries of IFC also suggest the problem through which fisheries can be affected including **Humans involvement.**

(3) Stocking management :- The international fisheries commission also helps in providing good stoking management of fishes. This commission make sure the way through which fisheries of certain species can be enhanced. The stoking management of fishes helps to improve the fisheries yield from particular region of ocean. The control of overfishing result in enhancement of fisheries. The stoking of those rare fishes is important which conducted by IFC organization. Lastly the international fisheries commission provides all the good health and life of fishes especially threatened and deep sea fishes.

The major importance of international fisheries commission is following :-

(1) Sustainable yield of fisheries :- Sustainable yield of fisheries of any particular species of fish is very much important. The yield of fish states the presence and healthy condition of fishes in certain region of ocean. The IFC ensure the the good sustainable yield of fishes. The data collecting from fish ground and calculate the fisheries yield, if the yield is not as much as correlates the good level of production, the IFC restrict he allowance of fisheries until the population achieved it's good number of population of fishes. Because of certain rules under the international fisheries commission, it prevent overfishing therefore the sustainable yield achieved.

(2) Ecosystem and food security :- This is one of the most valuable importance of fisheries commission. However the commission do not directly influence but the IFC control all of it's part and conserve ecosystem of fishes. The IFC commission provides sustainable yield which used to increase the value of food securities of fishes. The major importance of IFC is the management of ecosystem because it largely focus of the protection and conservation of ecosystem thereby fisheries production can be enhanced.

(3) scientific conservation :- as I mentioned that it has great role in scientific study and conservation of fishes which overall make good fishes life and capture pf it. It also makes dtata on part and present fisheries yield from any certain countries and their region.

Inland capture fisheries

The Inland capture fisheries which generally performed in freshwater and brackish water system, contributes around 30% of total fish production. Andhra pradesh is the first leading state in india which produce largest inland capture fisheries. Being a second largest fish producing country in the world after china and third is Indonesia. In India the major inland fish producing stats are andhra, west bengal, kerala gujrat, odisha, bihar etc.

The inland capture fisheries contributed by river system, tank, pond, estuary, canals and wetland. These are the major source which contribute the inland fisheries of india. Out of these source, the river system is one of the largest and biggest source of fisheries from this system but tanks, ponds and another source of inland capture fisheries also perform on large scales but not as enough as river system. One of the biggest advantage of this fisheries system or inland fisheries is that it's applicable of capture and culture both of the process but in contrast to marine which mostly applied for capture. The inland capture fisheries resource are following type :-

1. RIVERINE FISHERIES RESOURCE :- The river fisheries resource is the largest fisheries resource in india which distributed allover the country. This system of fisheries resource have consist several individual river system and their small tributaries. The major five river system are following :-

(1) The Ganga river system :- The Ganga river system is the largest system of all river system in india. The ganga which consider to be very sacred according to **Hindu** religion is also a good resource of fisheries. This river system extended over Bihar, Uttra pradesh, uttarakhand, arunachal pradesh, jharkhand, west bengal, Madhya pradesh, Delhi etc. The ganga river system divides into two system called as The Ganga and The Yamuna system. The Ganga system originate from Gangotri which further divided into several tributaries;- Gandak, Gomti, Kosi etc. The yamuna system originate from Yamunotri which consist these tributaries;- Sen and Chambal tributaries.

The Ganga :- Gomti, Gandak, Kosi.

The Yamuna :- Chambal , Sen.

The ganga river system contribute major role in fisheries because of it's alkaline nature of water, it provides good place to rapid growth of the fish life. The major fisheries occurs in the ganga river system is of Carps:- Common carps, Grass carps (*Ctenopharyngodon idella*), Catla catla, Labeo rohita. Catfishes like *clarias batrachus*, *Heteropneustes fossilis* and others. Invertebrates like prawn, crabs are also used to capture and culture at large scales. For all these aquatic creature we used several distinct process to capture from water bodies for example, Gill net, Purse net, Drag nets are used for capture the fishes and invertebrates.

(2) The Brahmaputra river system :- The brahmaputra river system is second largest or major river system in india which originate from mansarover. This river system covers some part of Nepal, arunachal pradesh, Assam, Sikkim , Himachal, odisha and finally empty into bay of bengal. Mostly east-northern part of india covered by this system. The brahmaputra river system have following tributaries ;- Manas, Lohit etc.

The major fisheries of this system consist of trouts, catfishes and some certain cold water fishes. The brahmaputra river fishes are also migratory fishes like salmon found in some tributaries of this river.

(3) Indus river system :- The Indus river system is not as much productive as upper two rivers contribute. It is also less extended river system that covers over Jammu and Kashmir, Uttarakhand, Pakistan, Gujarat, Punjab etc. This river system tributaries are Jhelum, Ravi is major tributaries of this system.

The major fisheries of this river system is:- Cold water fisheries like Mahseer, carps, catfishes etc.

(4) East coast river system :- East coast river system as name implies that it extended around east coast of India. This river system distributed in West Bengal, Andhra Pradesh, Tamil Nadu, Odisha and some part of Karnataka. This river system have many tributaries like Mahanadi, Krishna, Cauvery and Godavari are major tributaries. These tributaries mainly originates from east coast and extended to all east and some part of west coast states. Catfishes and prawns are major fisheries resource of this river system.

(5) West coast river system :- The west coast river system consist of Narmada and Tapi are two major river system in west coast which is found in west coastal states. These tributaries originating from west coast and covers Maharashtra, Kerala, Karnataka etc. The fisheries resource from this system are Catfish, carps, prawns and snails are major fisheries resource from this river system.

The Indian major carp or IMC included Catla catla, Labeo rohita and Cirrhinus mrigala contribute around 60 percent of total fish production from freshwater system. The great amount of these fishes are found in Ganga, Brahmaputra and east and west coast river system. The minor carps like Labeo beta and Cirrhinus reba are minor carps which contribute less account to the fisheries.

Cold water fisheries resource

Fisheries resource of India are greatly influenced by different source in India which has great environmental diversification. The next major resource of fisheries is cold water system. Cold water resource of fisheries are mostly found in Himalayas area or high hill areas like in India these kind of condition mainly found in those region where the water temperature always remains between 5.5 to 22 degree Celsius. The temperature should not be above 25 degree Celsius even in any season. Between these temperature range fishes called as cold water fishes. The Himalayas region are major resource of these fisheries because the low temperature is characteristics of those places. How they survive in such a very low temperature? The answer is crystal clear that they adapted themselves in those low temperature. Despite of low temperature they can easily sustain their life without much difficulties.

As we know that cold water is enriched with high oxygen content than warmer water therefore the fishes who conduct themselves in cold water can easily extract oxygen from surrounding by their gills. These cold water fishes contribute large range of fisheries to total production in India. The fish demand of cold water fisheries are also great due to high content of nutrients are present in it.

There are following major fisheries resource of cold water :-

(1) Mahaseer :- The name mahaseer is entitled to big head. These fishes are found in large body size. Mahaseer are cold water fish which found in temperature range between 5 to 25 degree Celsius. Mahaseer contribute large amount of fish production from cold water resource. The commercially important species of this fish are Tor tor, Tor putitor, Tor remadevii and or khudree are very important species of mahaseer which largely used as food fish.

All cold water fish found in cold water region, Mahaseer mostly found in Himachal Pradesh, Uttarakhand and also in Jammu, Assam etc. Mahaseer are barbs fish which have cycloid scales on their body. It's a Grey, yellow, brown coloured fish with single dorsal fin.

(2) Trout :- These fishes are migratory and cold water fish found in cold water region. The existing location of these fishes in India are Ladakh, Kashmir, Arunachal and other hilly area in India where the temperature remains around 15 degree Celsius. Trout are classified into two groups one is exotic and another is Indian or snow trout. Snow trout belongs from cypriniformes which have single but long dorsal fins and these are barbs fish group. Snow trout are not very much important in commercial point of thoughts. These snow trout like schizothorax species.

Exotic trout are rainbow trout and salmon (brown trout). Rainbow trout are also called *Oncorhynchus mykiss*. Another exotic trout is salmon fish.

(3) Common carp :- Common carp or *Cyprinus carpio* is also a cold water fish. This fish is very diverse because some species of it's found in warm and some in cold water. Common carp is found mostly in Kashmir, Himachal Pradesh, Bihar, Tamil Nadu, Karnataka etc.

(4) *Labeo rohita*

(5) Hill trouts

The major problem of this fisheries is the management and handling. The fish growth from this region is very slow because as we known that growth of fishes influenced by temperature where the cold water greatly influenced it. The processing and production of cold water fishes from this region is also declined as per day due to many distraction and local management.

Lacustrine fisheries

The fisheries of pond and lakes are described as lacustrine fisheries. India is second largest fish producing country in the world after china. India being a maritime country which surrounded by sea from three side. In india the fisheries supported by many resources and lacustrine is one of the resource. Lacustrine fisheries is mostly done in lake and pond so the name is also indicating term lake. The pond is somewhat smaller and low in depth than lake. The lake is also defined as the inland depression on earth surface. Lake can be formed by either volcanic activity or also through the small part of sea like chilika lake in odisha. The lakes and pond generally considered as same here. On the basis of their productivity the lacustrine fisheries classified as following lakes :-

(1) Oligotrophic lake :- The oligotrophic lake is type of lake which classified accordingly to amount of presence of nutrient molecule. The oligotrophic lake consist of low amount of nutrient in water body. Oligotrophic lake is less productive and the amount of nutrients are not enough. The nutrient molecule like planktons, small fish and grasses and amino acid, protein source food are less in this type of water body therefore the fish rapid growth inhibited.

(2) Eutrophic lake :- Eutrophic lake is type of lacustrine which is enriched with many nutrient molecule. The planktons and all the nutrients type are productive in this pond or lake.

(3) Dystrophic lake :- This type of lake is very much less productive for fishes. Due low amount of nutrient, fishes unable to survive in dystrophic lake.

Lacustrine fisheries is very challenging but good profitable fisheries. The fish growth completely depends on the type of lake or pond therefore the fishes grow fastly. The lake system is controlled fisheries capture or culture which have many benefits to easily culture and sell it.

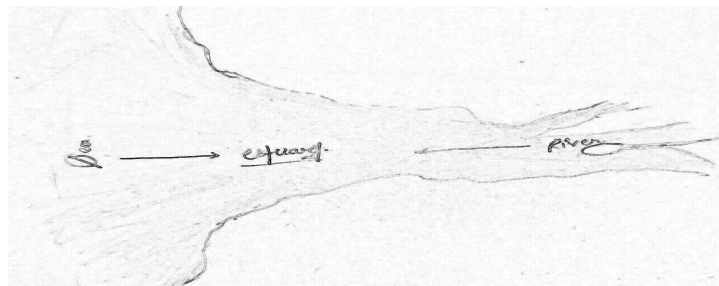
In india the major lakes are Dal lake in jammu kashmir, wular lake in jammu kashmir, Chilika lake in odisha, Vembanad lake in kerala, Loktak lake in manipur and Nainital lake in uttrakhand are very popular and important lake in fisheries point. The chilika lake is one of the largest lake in india and it's a type of lagoon lake which located in odisha. Chilika lake is also a type of brackish water lake where the major fishes are catfishes, carps and some invertebrates like prawns.

The major fisheries from this system reservoir are carps, catfishes, sunfishes, perch fishes and some trout and salmons fish. The lacustrine fisheries contribute by species:- Cyprinus carpio, Labeo rohita, perch fishes like Tilapia, mullets and anabantiformes. Trout involve the fisheries of schizothorax species of snow trout and rainbow as well as browntrout species. Mrigala also cultured in lakes of indian lacustrine fisheries system. The development and management of lacustrine fisheries are based on type of problem originating in fisheries For example, the lake processing and unbalance. The water quality also decides the productivity of fish culture and capture.

Estuarine fisheries

The fisheries which perform in Estuaries and lagoons are termed as brackish water fisheries or estuaries. The estuary also define as the mouth of great river system where the tide of ocean and current of river meets each other. In other term the estuary is the semi-enclosed coastal area which have high range of salinity. Simply, estuaries or brackish water fisheries are those which take place in such a region where the freshwater and marine water meets together. The estuaries fisheries involves great range of fishes which have ability to tolerate great range of Ph. The salinity of estuaries water or brackish water is between 0.5 to 35 ppt (parts per thousand). The grate range of salinity shows great fisheries resource. The estuaries forms at the region where the sea coastal meets river current therefore the fishes which found in this region have ability to tolerate the ranges of salinity.

The estuaries is highly productive and rich with verities of nutrients. As we know that india have different resource of fisheries like riverine system, lakes and other wet land reservoir where estuaries also contribute enough fisheries to indian total production of fisheries. India surrounded by sea at three sides where west coast surrounded by Arabian sea, East coast by bay of bengal and third is indian ocean at lower side.



In india there are so many estuaries which are functionally contribute very good fisheries production. The important estuaries in india are following :-

- (1) Hooghly matlah estuarine :- Hooghly matlah estuarine is the largest estuaries in india. Hooghly matlah estuarine found in west bengal which form the largest mangrove called sundarban. The major fisheries from this estuaries are milk fishes, herring, Perciformes fishes, shark catfishes, mystus species etc.
- (2) Godavery estuaries :- Godavery estuary located in east coast of india especially in Tamil-Andhra. Contribute great catfishes fisheries, carps and prawns.
- (3) Krishna estuaries :- Located in Tamil nadu in east coast.
- (4) cauvery estuaries :- Located in east coast.

(5) Chilika lake estuaries :- it's a type of lake but also classify under the estuaries of brackish water. It is located in odisha. The chilika lake is lagoon type estuaries.

Problem originating in brackish water fisheries or estuaries :-

(1) Overfishing:- When fish stock decreases from it's adequate level in certain region of water, it called as overfishing. The major problem of estuaries or for any fisheries culture is overfishing. The overfishing destroy all the fish life which is very hard to recover. The brackish water fisheries including several catfishes and carps but due to high demand of fishes in the market cause to destroy the certain fish population that is very damaging to their life. Overfishing is damaging in any fishing culture and capture and estuaries is one of them. The overfishing deplete the good stock of fish.

(2) Habits distraction :- Habit distraction is directly linked to overfishing. The stocking of fishes is termed as habit of fish which can be disrupt by over fishing and this is also one of the major problem of brackish water fishes. The fish habit where they lives are greatly influenced by several changes in water. The Brackish water fish stock and their habits depleted by their habit distraction.

(3) Climate change :- As per population increasing the many problem also evolving through it and the brackish water fishes also influenced by these pollution created by several factories near to coastal and fish life region. The change in climate is one of the big problem of all fisheries industries. The temperature, season and several other changes is major thing that occurs in the climate changes.

(4) Non-target fishing :- Sometime the rare or already threatened species of fish caught in great amount which is completely indicating the loss of certain species. The different type of gears including trawl net and drag net is one of the very dangerous enemy of fishes because these nets also catches those species which is not targeting to catch it but it trapped into it therefore it become more critically endanger . The non-targeting fishing can be understand by breathing for example we breath but during inhaling all gasses in air inhaled but we wants only oxygen. Similarly in fishes because of using some nets and gear cause to capture those species which do not wanted to catch.

(5) Ph change:- As we know that brackish water salinity range from 0.5 to 35 ppt but due to great change in Ph can damage the certain pH sensitive fishes. However fish in brackish water is very well adapted to survive in range of salinity but due to great changes also cause to damage. Temperature and Ph somehow irritating for certain group of species for their distraction.

Marine capture fisheries

The fisheries resource of india from marine source is termed as marine fisheries resource. The marine fisheries resource is mostly capture fisheries but inland fisheries resource contribute both capture and culture fisheries.

India being a tropical country which contribute several fisheries of different fishes and aquatic organism. India become the second largest fish producing country where china and Indonesia on first and third respectively. In india the marine fisheries resource is the major fish producing sector where not only fishes are captured rather different invertebrates and aquatic plants and some other sea creature are captured at large scale for different purpose for example some capture contribute to food industries while others are responsible for commercially and recreation purposes. As we know that fishes are enrich with so many good nutritive molecules and vitamins as well as good fats especially omega 3 fatty acid for example linolenic fatty acid. In general the most abundant vitamins in fish muscles is vitamin A and vitamin D which contribute 80 percent of vitamins in fishes.

India is a maritime country which has approx 8'100 km coastline area and 2.02 kilometer square EEZ or exclusive economic zone. Because of Large coastline area and EEZ, india produce great number of marine aquatic organism including fishes at wide scales. India is surrounded by sea on three side. One side surrounds Arabian sea on west coast of india, second side surrounded by bay of bengal on east coast of india and third surrounds indian ocean. The major fisheries of marine resource come from following states in india :-

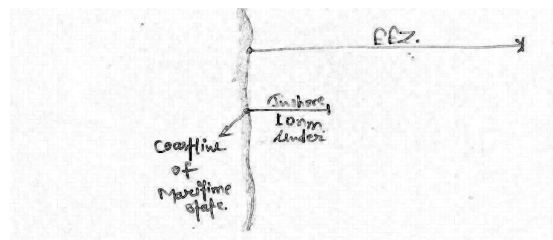
- (1) Gujrat on the west cost of india.
- (2) Kerala on west coast of india.
- (3) Karnataka on west coast of india.
- (4) Tamil nadu and andhra pradesh on east coast of india.
- (5) West bengal on east coast of india.

These are the major fish producing states in india. Out of these major fishery contributor states in india, Gujrat is first top state for marine fisheries producer state in india where andhra pradesh on second but the data may varies according to yield per year. The major fisheries resource of marine sector come from west coast like Gujrat, Karnataka, Maharashtra and kerala but Andhra pradesh and tamil nadu also contribute very good amount of fisheries. The west coast contribute about 70 percent of total marine fish production in india but the fisheries from east coast contribute only about 30 percent fisheries from indian marine resource but again the exact data may varies every year. The major thing that comes to focus is the productivity and oceanographical conditions in west coast and east coast of india. Therefore the west coast of india is consider as high productive and contribute more fisheries resource than east coast. The presence of planktons and fish food also determine the yield of fishes from certain coast.

Due to lack of instrument and gears we had so many difficulties in past decade while capturing the fisheries from marine resource in past decades was difficult but now due to modernization and developmental tools, the indian marine fisheries resource growing and fisheries performed by different gears and nets.

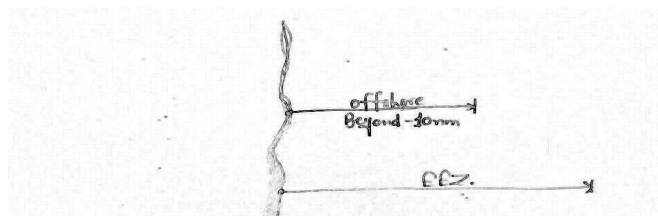
There are following fisheries resource of marine in india :-

(1) Coastal and inshore fisheries :- The inshore fisheries is a fisheries practice which perform within a few kilometer from coastline of maritime states. It's a very common marine fisheries resource of india where the maritime states of their country practice the fisheries in near to shore. The inshore fisheries mostly done under the 10 nm from coastline. Due to almost free resource of fisheries in inshore, fisherman use too much resource therefore the production decline day by day. The inshore fisheries is very common and have no any restriction to capture the fishes therefore mos of the fisherman practice and yield marine fisheries from it. Fisherman use ancients method to capture the fisheries and then sell it in market market.



The contribution of inshore fisheries resource in india is not very much but this is household income resource for may people who practice in it. The overfishing is very very high in this part henceforth it must have to control and over come from this damage.

(2) Offshore fisheries :- The offshore fisheries of india is wide type of marine fisheries resource which done beyond 10nm from coastline of marine but under the EEZ. The offshore fisheries is a practice of fisheries resource which performed very far from shore line but within the rights of maritime states or 200nm (for india 350nm). The fisheries of this resource is produced at large scales and the traffic of fishing in this resource is also very less therefore the yield also enhanced. It is advanced marine fisheries resource of india where the fisheries perform by some mechanical and modern tolls and boats or gears.



There are following marine fishes from their region:-

(1) pelagic :- The pelagic fisheries resource found in pelagic region or rather than floor of ocean. These are mostly shoaling and schooling fishes including; tuna, herring, milk fish, bombay duck, anchovies, oil sardines, lesser sardines and some species of Tetradontiformes.

(2) demersal fisheries :- the fisheries found in floor region called as demersal. In which includes most of the sharks, rays, skates, catfishes, eels etc.

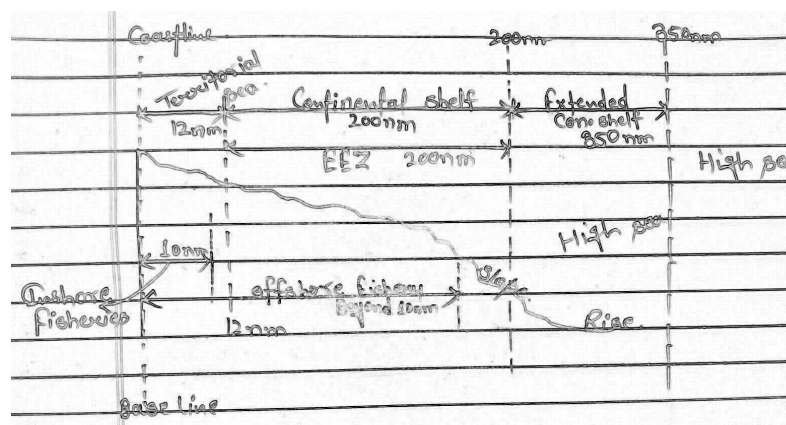
Fisheries resource of continental shelf

As we know that india is second largest country for production of fishes in the world. India is maritime country which covered by oceans and sea on three side where one on east coast by bay of bengal and Arabian sea on west bengal and indian ocean at bottom of indian map. The total average coastline is about 8,100 km and 2.02 km square EEZ. Due to large coastline and shoreline of india, the production of fishes and other aquatic organism including certain plants are also known.

First

we have to understand that what is the meaning of continental shelf? **The continental shelf is the submerged area of maritime continent by shallow water.** The continental shelf is mainly present under shallow water but not enough deep than high sea and deep sea. The continental shelf originate from territorial sea which end at exclusive economy zone but certain country like india have extended continental shelf upto 350nm from territorial sea. In general the continental shelf distributed upto 200nm along with EEZ but for extended continental shelf the distance increased.

The continental shelf is the richest part under entire EEZ because of the presence of most fish species and important aquatic organism with many planktons and food molecules. The continental shelf generally start after the territorial sea. The territorial sea which has inshore fisheries and this territorial sea extended upto 12nm from baseline of coastline of maritime state of that country. Under the continental shelf included inshore and offshore fisheries because inshore fisheries are those fisheries which generally done under the 10nm from coastline of sea while offshore fisheries are those fisheries which perform beyond 10nm from baseline but under the EEZ of the sea. Continental shelf is not continuously extended and nor plane upto EEZ rather the continental shelf have so many it's internal parts. As in mentioned that continental shelf have shallow water due to less depth, are greatly divided into continental break, continental slop, continental rise. The continental slope then form rise, when it meets the high sea.



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As we know that continental shelf is very nutritive place for good growth of fishes and also for many invertebrates and plants. The fisheries resource of continental shelf are greatly diversified in india. The major fisheries resource of continental shelf included two fisheries system one is inshore fisheries and another is offshore fisheries. As previously discussed that inshore fisheries perform under 10nm from coastline of any maritime state and offshore beyond 10nm but under the EEZ. The major fisheries from this site includes marine fishes, invertebrates and some commercially important aquatic plant which have high demand in market's. The fishes included mullets (Mugil cephalus), milk fishes and mostly catfishes contribute the fisheries from continental shelf like iridescent shark or catfish shark, marine catfish spp., and salmons, polynemids, pomfrets, sardine and also bombay duck from Maharashtra especially and anchovies.

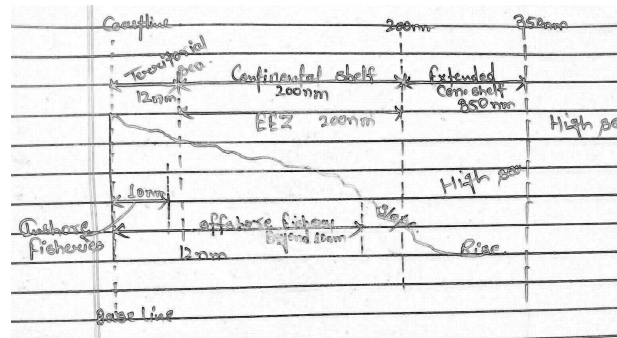
EEZ or Exclusive Economic Zone

India being a tropical country which surrounded by sea on three side and termed as maritime country. One side through Arabian sea on west coast of india and east coast surrounded by bay of bengal and indian oceans at tamil and kerala side or south of india. India contributes good production of fishes and also other aquatic organism to total global production. Approx 8'100 km coastline and 2.02 km square EEZ. These large coastline and resource contributes very well in fisheries.

EEZ refers as exclusive economic zone which was established by united state in 1982. exclusive economic zone is an area where the certain maritime states of that country have rights to use the resource which extended upto 200nm (nautical miles) from coastline of states. Some data states that EEZ may start from territorial sea. Territorial sea is a small region which start from baseline upto 12nm. The main purpose for building the Exclusive economic zone is to maintain the resource which given by nature in the ocean. Therefore the the EEZ have rights only to use the oceanic resource which have included fisheries, aquaculture, wind power plant etc. but only under 200nm. Some country have rights upto 350nm from coastline sea because those have extended EEZ like india. The exclusive economic zone consist continental shelf, inshore fisheries, offshore fisheries and continental slopes. High sea termed after EEZ which is much deeper than the region of EEZ. The continental shelf is an area of maritime state which have submerged under the shallow water. The continental shelf is very nutritive region because of presence of nutrient molecule in this place.

EEZ fisheries like inshore and offshore fisheries which perform under 10nm and beyond 10nm respectively but the offshore fisheries only done within the EEZ. Wind power plant is also perform in EEZ region. The certain states in india have already started this potential use of resource.

Other than wind power production, the EEZ also used as great resource. Some country allow the rights for pass the flights or commercial flights across the EEZ of country.



There are following exploitation of exclusive economic zone of underexploited resource :-

(1) Fisheries resource :- the exclusive economic zone provide one of the first and prime rights to use fisheries resource in the EEZ region. The fisheries resource in this part also high because of high productivity of water and therefore the offshore and inshore fisheries come to point which contribute their role in production of fishes and many other aquatic organism. The fisheries resource under EEZ is the only resource for countries to use it because beyond EEZ the use of fisheries resource get restricted. The underexploited resource of EEZ can be used to increase the fisheries resource of country. Due to lack of instrument and investment on this area, the most of the resource are still in underexploited in some countries. These area can be exploited by using advanced tools and technique.

(2) The wind and tides potential :- The EEZ can be also used to generate energy. As our population increases, increase their needs and one of the great rudiment of people is the electricity or power. The EEZ region is such a region where the speed of wind is quite high which can be used to generate power. In india this technique already launched and working. In some countries because of lack of investment and tools they can't use but it can be utilized to get benefit. So this is also one of the underexploited resource of EEZ which can be exploited easily.

(3) Resource for Minerals :- The EEZ can also be utilize for minerals. Because as we know that the oceanic sediments are very very enriched with verities of minerals and molecule. These molecules involves zinc, copper, iron, sulfur etc. These mineral are much more in the sedimentary area of the EEZ. This is also one of the unused resource for many countries because of underdevelopment and lack of instrument. These minerals can be exploited to use for many industries to make many different kind of products.

(4) Biotechnological purposes :- The EEZ is the school of verities of molecule, gases and bacteria. The EEZ is use for extracting those valuable molecule and material that have high demand in market. The verities of product can be used to form from these exploitation.

The resource of all these things is somehow costly because its required lot of tools and ideas to get and use it therefore very certain countries are able to use.

Pelagic fisheries

As we know that India is a tropical country which is surrounded by ocean and sea at three sides. Arabian sea surrounds the west coast, east coast surrounded by Bay of Bengal and at the bottom is the Indian sea. India which has 8'100km coastline and 2.02km square of EEZ or exclusive economic zone. These large coastline areas contribute to a large number of fisheries production. Great diversity in nature of Indian climate, different resources have been classified in India for production of fisheries. On average, 4.50 million one fish production has been determined last record.

Fishes in the sea or ocean divided into two groups on the basis of column of water. Fishes of surface area and sub-surface area are termed as pelagic fish. Pelagic fish do not associate with bottom instead they live in the mid-column or at the surface of water. Those fishes which mostly spend their life cycle at bottom or sediment of the water column called as demersal fishes. Pelagic fishes include tuna, mackerel, mullets etc. These pelagic fishes are mostly active swimmers. The pelagic fisheries of India are one of the resources which contribute good production of aquatic organisms. As every country has only rights to use resources under the 200nm from baseline or territorial sea.

In India the pelagic fisheries resources include tuna fisheries, mackerel fisheries, mullets fisheries, milk fisheries, anchovies fisheries, sardines fisheries, oil sardines, herring fisheries, Bombay duck, clupeids.

Fisheries of different pelagic fishes :-

(1) Sardines :- In Indian pelagic fisheries, sardines fisheries is one of the major fisheries production which contribute around 30% of total fish production from all marine production in India. As this fish is known for rich oil and water which is normally found in west coast of India due to enrichment of its nutritive foods. Most commercially important fish species from this fish is *Sardinella longiceps*, *Sardinella gibbosa*, *Sardinella fimbriata* etc. contribute major fisheries from this fish. These fishes have single dorsal fin and elongated and blunt head. They are active swimmers.

(2) Lesser Sardines :- Lesser sardines are similar fishes to sardines. Lesser sardine has small size and less active and less coloured than sardines. The major fishes from this fish are contributed by *Dussumeria albela*, *Sardinella fimbriata* etc. Lesser sardine contribute 8% of the total fish production.

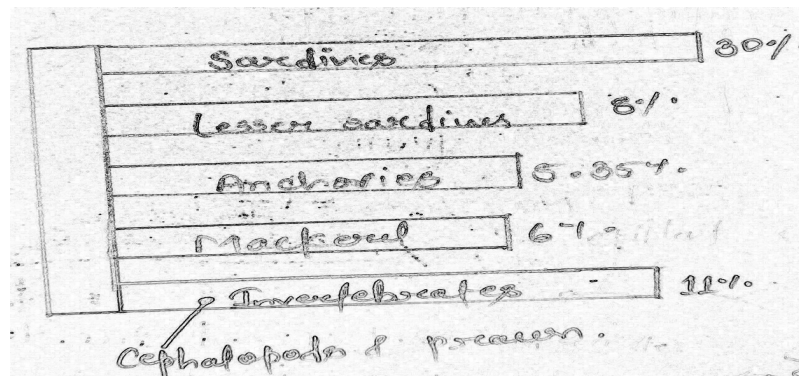
(3) Anchovies :- Anchovies are pelagic fishes which are active swimmers. The major species of anchovies are *Anchoviella commersoni*, *Anchoviella indica*, *Anchovia dussumeria* etc. are major fisheries which contribute great fisheries to total fish production from marine resources around 5% to total production.

(4) Clupeids :- Clupeids mostly found in east coast but some are also present in west coast of India. The major fisheries species of clupeids are *Hilsa ilsha* which contribute very good fisheries to total production of fisheries.

(5) Tuna :- Tuna is one of the most valuable and active swimmer fish. Its fisheries mostly found in west coast of India than east coast. The major fisheries of tuna is *Thunnus thynnus*, *Thunnus albacore* etc. which belongs from Scombriformes order and Scombridae family. It is estimated around 2 lakh to 4 lakh metric tonne total production of fishes from marine resources.

(6) Mackerel :- This belongs to scombriform and scombridae family have single commercially most important species which is *Rastrelliger kanagurta*. Contribute about 6% to total marine fish production.

(7) Invertebrates :- Invertebrates, prawn and cephalopods contribute around 11% of total invertebrate production. On recent data it is estimated that prawn contribute around 5.13% and cephalopods also toward the 5%. The main species of prawn which makes production are tiger prawn (*Penaeus monodon*) and white prawn (*Penaeus indicus*) and from river prawn are *Macrobrachium rosenbergii*. In cephalopods there are two orders which produce data are coleoidae and nautiloidae which contribute octopus, squids, cuttlefish.



Demersal fisheries

Term demersal refers to the fisheries or those fishes which are found near to the bottom which is not associated with the surface. But it does not mean that they never come to the surface; instead, once in a while they come to the surface not only for taking oxygen because as we know that marine fishes are enough capable of extracting oxygen from water by well-defined gill and ram ventilation.

As India being a tropical country which has approx 8,100 km coastline and 2.02 million km square exclusive economic zone. India is the second largest fish-producing country in the world which is supported by both inland and marine fishes. Marine fishes where majority support only capture fisheries while inland contribute both capture and culture. In India, annual fish production data can vary but from the last two years the production of fishes declined very rapidly. According to recent data estimated around 4.50 million tones which rapidly declined to 2.32 million tones. It may be reasoned that overfishing causes decline in fisheries.

Demersal fishes as earlier mentioned that their fisheries are found near to the bottom and sediment of the oceanic floor which have included the fisheries of most marine catfishes, eel, prawn, Bombay duck, and elasmobranchii. Why elasmobranchii so because in demersal fisheries we also take the fisheries from mid-water or just lower the mid column of water.

Demersal fisheries are one of the fisheries which are captured by well-developed equipment and boats and gears because it is active fishing; therefore, for this fisheries required mechanical machines to drag and pull the net or gears. The major demersal fisheries production comes from the west coast of India.

than east coast. One of the reason I want to mentioned that on west coast there is great diversity and different source of nutrient which those preferred those fishes.

There are following fisheries of demersal resource :-

(1) Elasmobranchii :- Elasmobranchii is one the most active swimmer fish in sea which is a cartilage fish, the major fisheries of elasmobranchii occurs from tamil nadu on east coat of india. The species constitute the elasmobranchii fisheries are belonging from Carchariformes, oreotolobiformes etc. Elasmobranchii constitute about 5 to 8.5 % of total marine fish production

(2) Bombay duck :- Bombay duck mostly found on west coast of india in Maharashtra and Goa which contribute about 4 to 9 % of total marine fish landings. It's very rich with water content and somewhat looks similar to catfishes and have diphyccercal tail. One of the important species is harpodon nehereus which forms the total fisheries in india.

(3) Catfishes :- Marine catfishes are major demersal fish which estimates about 6 to 8 % of total fisheries landings from marine resource. The important fishes are come from Ariidae, bagridae and pangasiidae. Mostly west coast is the leading coast for production of catfishes.

(4) Silver bellies :- Silver bellies form about 3 % of annual fish production from marine fisheries. Silver bellies is perchomorpha that have perch like body form and generally it is coloured fish. Most important commercially fish of silver bellies is liognathus equulus, liognathus bindua etc.

(5) Pomfret :- Pomfrets are Percomorpha fishes which found in west coast than east coast which contribute about 5% of total marine fisheries. The pomfrets pampus species are also perch form body which contribute less fisheries to annual production.

Biological aspect of fisheries management

Fisheries is a growing industry of commercially, food resource and other purposes. The increasing demand for aquatic life included fishes at high as food, decline the fisheries resource at hand. The overfishing and over capturing of aquatic organism directly influence the young fish generation for future fishing. So the fisheries resource have to manage properly for better production of fisheries in each yield. The management of fisheries included following way :-

(1) Population dynamics :- Population dynamics is the change in population, distribution and number of organism over time and place. These change in number and population trigger by change in fish stock in particular place. For example to understand the meaning of change in population dynamics, there are 100 species of fish in a region in which 90 species caught, rest of 10 species are

not able to produce and maintain the population again and this termed as overfishing condition. So if once the population change controlled, management of fisheries also controlled.

(2) Ecosystem management :- Ecosystem is one of system in which every organism sustain their good and surviving life. In fisheries, the management of fisheries is to manage the ecosystem first because if the ecosystem is proportional to fisheries life then the production of fishes increased. Ecosystem management require several factor which provide good environment for fishes life. Pollution, noise, water disturbance these are factor for ecosystem management so management of fisheries requires management of theses ecosystem factor like controlling on pollution, noise etc.

(3) Nutritive management :- The nutrition decide the life and yielding of fisheries. The abundance of nutrition component increases the growth rate of fishes. Management of fisheries hence influenced by presence and absence of nutritive molecule in water. If the essential molecule in water is high, fishes growth rate influenced rapidly.

(4) Overfishing and pollution :- These two factor is one of the fundamental reason for declining the fish growth, fish production and overall life of fishes. To manage and control the overfishing and pollution, increase fish growth and life of aquatic creature.

Population dynamics

Fish is a cold blooded aquatic organism which have great nutritive value in the market. The fish is not only important for economy but also for many essential nutritive value like essential amino acid and proteins and vitamins. Fish being a aquatic organism but some are also air breathing fishes which contribute very good role in making ecology. In india the major fisheries production is contributed by Gujarat and andhra pradesh. The fisheries is a growing industries which provide verities of opportunities for employment and scientific research.

The population is a group of organism belongs to the same species or it's related which spend their life together for many purposes including reproduction, protection and fight against predator, and feeding behavior. The term population states the group or aggregation of organism together, in fishes the population can be express as aggregation and schooling. Fish population is also an association of group of organism who live together. The term dynamics refers "the change in something". The dynamics is change over time of anything for example a fish swimming from one habit to another habit over a time therefore fish dynamically migrate over certain time period.

Overall population dynamics explain that change in population, distribution and number of organism over time period or place in response to birth rate, death rate, emigration and immigration. In other term, the population dynamics says that population of any organism changes over certain time by adding and removing the factors. Population dynamics is scientific term which used to

describe the stocking and population of organism in particular region. In contrast to fish, the population dynamics explain the change in population of fish over time in response to birth, death, emigration, immigration. The actual meaning of change in population is influenced by birth of fishes, death of fishes or also migration of fishes. For example to understand the population dynamics, there are 100 fish species population who living in certain aquatic area, the change of population can be either by birth, death or migration. If birth occurs, population increases from its previous data number, if death occurs, fish population decreases. Migration of fishes also influence the fish population by adding or leaving of fishes. So change in population, distribution of organism occurs in response to these major factor.

As we know that india has great coastline around 8'100km and 2.02km square EEZ. India is also second largest fish producing country after china. Due to modernization and availability of tools fishing become easier than earlier which contribute to the production of fishes. **There are following importance and advantage of understanding the population dynamics of fishes :-**

(1)sustainable yield:- the population dynamics used to increase the production of fishes. The population dynamics works upon the fact that it conducts the fish growth, death and migration , through these fact the sustainable yield can be enhanced by improving these facts. Population dynamics gives an idea about nutrient availability in pond, tank, river or any places where fish lives. Because If we take one example, if the population dynamics data says that fishes declined from previous data then it assume that the nutrient molecule in those water for fishes declined but if data of population dynamics increases then nutrient availability presence in pond also increased. So scientist can find that availability of nutrition in water of pond, river, tank etc.

(2) Conservation of fishes :- The population dynamics also used to avoid the root cause of fish decline in number, called overfishing. The population dynamics also used to conserve the fishes. Conservation can be possible by understanding the data which state about fishes growth, birth, death and emigration and immigration of fishes. If the immigration of fishes in particular area of water in increased then the fish stock in those area also increased which focus on the conservation of fishes.

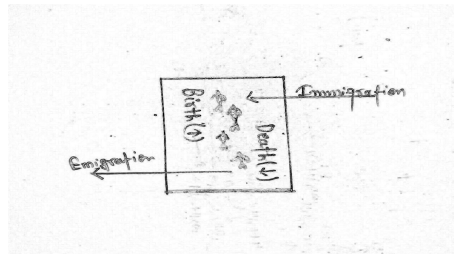
The problem of overfishing:-

(3) Decline in sustainable yield :- The fish production in india is decline from past five year, the major reason for this reason is the overfishing. The overfishing destroy all the fish life in such way through which the fish can't replace its population. The overfishing greatly impact on the sustainable yield of fishes each year. The sustainable yield can be understand by the fact that how much fish landing occurs every catch. If the sustainable yield is good according to data then the overfishing is fall under-control but if the yield is very less then its big problem.

(4) Destruction in ecosystem :- The overfishing is major problem for the fish because fish is now widely used for food but human disturb fish population rapidly than fish cover-up their deletion. The fish is good maintainer of ecosystem but due to great impact of overfishing of fish population

cause to completely destruction of ecosystem which present under the water. Indirectly the overfishing also destroy other organism ecosystem who depends on fish for verities of reason like food, aggregation etc.

(3) Impact on economy :- The very fast growing industry of fish culture and capture contributes great economy and employment to people. The overfishing damage all the way of economy and employment.



These are major root impact of overfishing. The overfishing is really deleterious for all the fish life and it's ecosystem therefore we have to take a big step to improve the fish ecosystem and it's related parts.

THE END OF SYLLABUS

Any suggestions for it's improvement will be acknowledge and incorporated.

Don't think this is a book, it's just a notes

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